PUBLIC BARIATRIC SURGERY IN TASMANIA: PATIENT PATHWAYS AND HEALTH SERVICE USE

by

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(Medical Research)

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Statement of Originality

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Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines of the Australian Government's Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University.

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Conflict of Interest Declaration

Alexandr Kuzminov declares no conflict of interest.

Co-authors of the chapters declare the following:

Martin Hensher reports that he was responsible for policy development and performance management of elective surgery and elective surgery wait-lists on behalf of the Tasmanian Department of Health and Human Services for much of the study period.

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Abstract

Background: Many patients eligible for bariatric surgery in Australia do not have private health insurance, which creates significant pressure on the public system, with prolonged wait-list times. Public hospital service use by this patient group is under-investigated. Australia-wide, public hospitals perform a higher proportion of revisional procedures than private hospitals (36% vs 25%), possibly limiting access to primary procedures. The aim of the study was to investigate the impact of bariatric surgery provision in the Tasmanian public sector on public hospital service use, particularly hospital admissions and emergency department (ED) presentation rates and to identify and describe revisional surgery pathways, including subsequent re-revisions.

Methods: A statewide retrospective cohort study was conducted of public hospital service use by all Tasmanian patients on the wait-list for publicly funded bariatric surgery from 2008 to 2013. Multiple administrative databases and data linked with the Tasmanian Death Registry were used.

Rates of hospital admissions in 2006–2014 and ED presentations in 2000–2014 were compared for operated-on patients and those who dropped-out of the wait-list. Public hospital service use was analysed in different periods: prior to wait-list placement, while on the wait-list, and after removal from the wait-list either after having a bariatric procedure or dropping out without surgery. Incidence rate ratios (IRR) with 95% confidence intervals (CI) for groups and periods comparisons were derived using a negative binomial regression mixed-effects model adjusted for sex, age and non-independent observation periods.

Hospital service use was analysed for primary vs revisional bariatric surgery recipients using similar methods.

A systematic review of revisional surgery outcomes, such as subsequent revisions and complication rates, was performed, including papers following at least 75% of patients for 12 months or more.

Results: The cohort study identified 652 patients wait-listed for primary bariatric surgery, of whom 178 (27.3%) had bariatric surgery and 236 (36.2%) dropped-out from the wait-list. Together, these patients had 3,120 public hospital admissions and 5,149 ED presentations. Number of days in hospital per year was higher for the dropped-out patients than for surgery recipients while on the wait-list (IRR 2.22, 95% CI 1.36–3.61). Hospital admission rates did not increase post-surgery (IRR 1.08, 95% CI 0.83–1.41) but days admitted per year did increase (IRR 1.53, 95% CI 1.01–2.34). ED presentation rates did not change significantly post-surgery compared with the waiting period (IRR 1.19, 95% CI 0.90–1.56). Presentation rates significantly increased for digestive system (IRR 2.02, 95% CI 1.19–3.45) and psychiatric diseases (IRR 4.85, 95% CI 1.06–22.26) after surgery. The likelihood of being admitted from the ED significantly increased after surgery (31.7% to 38.9%, $p<0.05$).

A total of 95 patients wait-listed for revisional surgery were identified; 91 (95.2%) of the patients were operated-on as planned, and two more had emergency surgeries after removal from the wait-list. Including subsequent planned and emergency revisions, of the 320 bariatric procedures performed with public funding for patients while wait-listed for bariatric surgery in 2008–2013, 142 (44.8%) were performed for revisional surgery. The mean primary surgery wait-list time was significantly ($p<0.05$) longer than for revisional surgery: 4.1 ± 2.8 vs 0.8 ± 1.0 years, respectively. Compared with primary-only surgery recipients, revisional surgery recipients had higher public hospital admission rates (IRR 2.60, 95% CI 1.63–4.13 while on wait-list and IRR 1.98, 95% CI 1.31–2.98 post-surgery); more days in hospital per year (IRR 2.68, 95% CI 1.44–4.99 while on wait-list and IRR 2.10, 95% CI 1.18–3.76 post-surgery); and higher ED presentation rates after the surgery (IRR 1.76, 95% CI 1.15–2.70).

For the systematic review, the search identified 28 papers (1317 patients with surgical revisions) following at least 75% of patients for 12 months or more. For adjustable gastric banding (AGB), rebanding had higher re-revisional rates than conversions into other procedures. Conversion of AGB to Roux-en-Y gastric by-pass had the highest number of short-term (10.7%) and long-term (22.0%) complications. We estimated 8.8% of patients required tertiary surgery, with 194 reoperations (tertiary, subsequent and for complications) per 1000 patients undergoing a secondary procedure.

Conclusion: Bariatric surgery performed in the public hospital setting in Tasmania was followed by an increase in hospital service use. Revisions represented nearly half of the public bariatric surgery procedures in Tasmania and were higher priorities. Revisional surgery in the public system, including revisions for primary surgery performed in the private system, limits access to public primary surgery. Future planning for bariatric surgery in the public sector should account for the increase in public hospital service use and demand for revisions, including tertiary and subsequent revisions and their long-term complications.

List of Abbreviations

AGB	Adjustable gastric banding
AIHW	Australian Institute of Health and Welfare
BMI	Body mass index
BSR	Bariatric Surgery Registry (Australia and New Zealand)
BPD	Biliopancreatic diversion
D-RYGB	Distal Roux-en-Y gastric bypass
DS	Duodenal switch
EASO	European Association for the Study of Obesity
ED	Emergency department
IFSO	International Federation for Surgery of Obesity and metabolic disorders
IFSO-EC	International Federation for the Surgery of Obesity – European Chapter
LAGB	Laparoscopic adjustable gastric banding
MDC	Major diagnostic category
RYGB	Roux-en-Y gastric bypass
SAGB	Single anastomosis gastric bypass
SG	Sleeve gastrectomy
T2DM	Type 2 diabetes mellitus
URG MDB	Urgency related group major diagnostic block
VBG	Vertical banded gastroplasty
WHO	World Health Organisation
WL	Wait-list

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Chapter 1: Introduction

1.1 Obesity as a problem

1.1.1 Definition of obesity

Obesity is defined by the World Health Organization (WHO) as a disease in which excess body fat has accumulated to such an extent that health may be adversely affected; however, the amount of excess fat, its distribution within the body, and the associated health consequences vary considerably among obese individuals [1]. This definition goes beyond the initial straightforward definitions by WHO, the Obesity Society (USA) with collaborators and the National Health and Medical Research Council (Australia) of obesity as a body mass index (BMI) over 30 kg/m^2 and overweight as BMI over 25 and less than 30 kg/m^2 [2, 3]. BMI is determined by measuring a person's weight and height and dividing weight in kilograms by height in metres squared. Obesity is divided into three classes (or grades): Class I with BMI 30.0–34.9 kg/m^2, Class II with BMI 35.0–34.9 kg/m^2, and Class III with BMI ≥40.0 kg/m^2 and more. When first introduced, this classification did not have any clinical or policy implications [4].

However, BMI-based classifications are used in the diagnosis of obesity as the simplest method, despite being only a surrogate measure and not providing an accurate representation of body fat composition [5]. BMI does not discriminate between lean and fat mass and does not take whole body fat distribution into consideration, therefore leaving a possibility of misclassification of persons of short stature or muscular build as overweight or obese [6] or underestimation of obesity among those with normal or overweight BMI but a body fat percentage within the obesity range according to the cut-offs for body fat percentage most commonly reported in the literature [7]. The BMI continuum should also be adjusted for the Asian population, which has different associations among BMI, body fat percentage and obesity health risks and comorbidities, compared to the European population for whom the guidelines and classifications were initially developed [8]. In addition, Polynesians have significantly higher ratio of lean to fat mass compared with Europeans, and for this population BMI thresholds should be increased [9, 10]. Moreover, these classifications do not include a direct assessment of comorbidities related to obesity or functional status [11].

1.1.2 Epidemiology of obesity

The prevalence of obesity worldwide has often been referred to as *a pandemic* with trends of increasing obesity in many countries [12, 13]. A global systematic analysis revealed that the prevalence of overweight and obesity between 1980 and 2013 increased by 27.5% for adults and 47.1% for children, with absolute numbers rising from 921 million to 2.1 billion [14]. This report found increases in both developed and developing countries for all sexes and ages, although in different proportions. There are certain regions with an estimated prevalence of obesity in over 50% of females (Kuwait, Kiribati, Micronesia, Libya, Qatar, Tonga, and Samoa) and males (Tonga). The estimated number of persons with obesity according to this report is 693 million, with more than 50% of those living in only 10 countries: USA, China, India, Russia, Brazil, Mexico, Egypt, Pakistan, Indonesia, and Germany. Despite the high absolute numbers of obese individuals in India and China, the prevalence of obesity there is relatively low (less than 5%). The report did not find any country with a significant decline in obesity rates within the 33-year period, suggesting that obesity rates will continue to increase, especially in developing counties.

According to the National Health Survey 2014–15 by the Australian Bureau of Statistics, 11.2 million (63.4%) Australians aged 18 and over were overweight or obese, with 6.3 million (35.5%) overweight and 4.9 million (27.9%) obese [15]. While the survey noted the increasing prevalence of overweight and obesity between 1995 and 2012 from 56.3% to 62.8%, the trend appeared to stabilise from 2012 to 2015. The prevalence of overweight and obesity is higher in Australian males (70.8%) than in females (56.3%). However, advanced obesity (Class 2 and Class 3) is more prevalent among Australian females than males (10.7% vs 8.0%) [16] (Figure 1). Obesity is more prevalent in Australians living in regional and remote areas compared with those in major cities. Females living in areas of socio-economic disadvantage are more likely to be overweight or obese than females in less disadvantaged areas, with no difference for males.

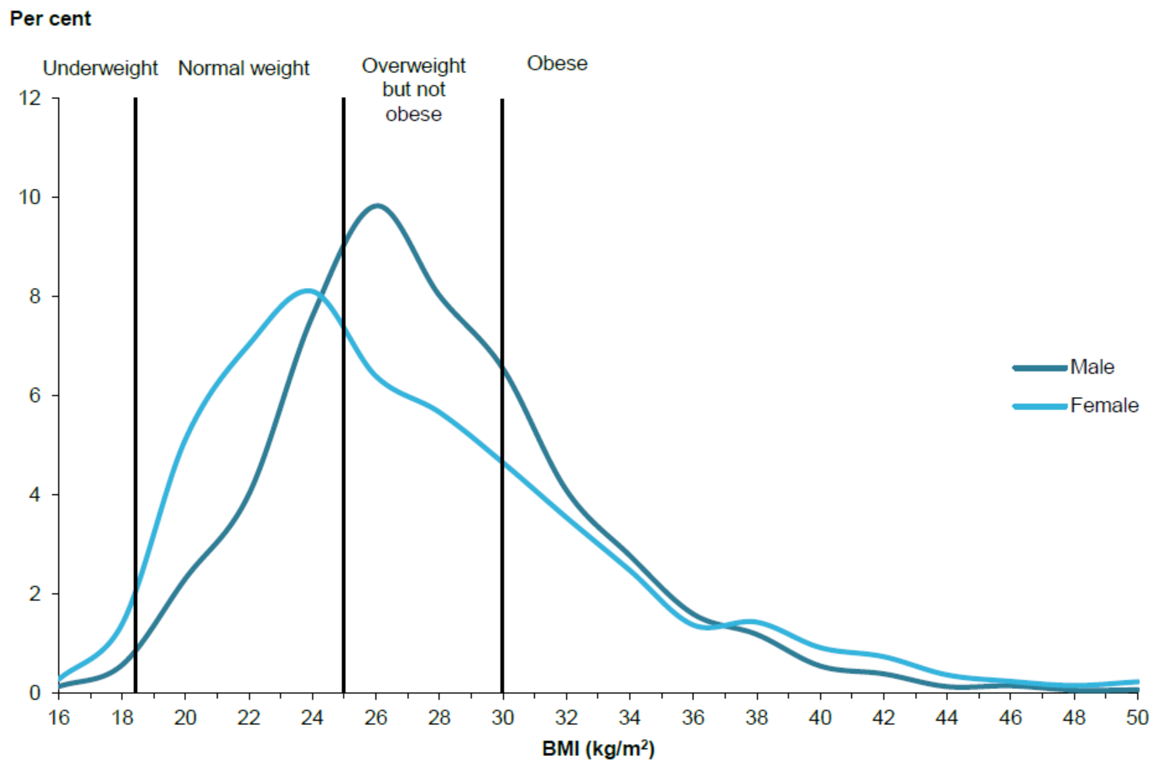


Figure 1. Distribution of body mass index in adults by sex, 2014–15 (reproduced from the Australian Institute of Health and Welfare, 2017 [16])

In Tasmania, the estimated prevalence of obesity is higher than the national average, with 68% of individuals overweight or obese, including 74% of men and 61% of women (Figure 2) [17].

1.1.3 Comorbidities of obesity

Obesity is associated with a number of medical conditions, including hypothyroidism, Cushing's syndrome, and polycystic ovary syndrome and is also an established risk factor for the development of a wide range of comorbidities, such as dyslipidaemia, type 2 diabetes, hypertension, coronary heart disease, stroke, obstructive sleep apnoea, osteoarthritis, and a number of cancers [18].

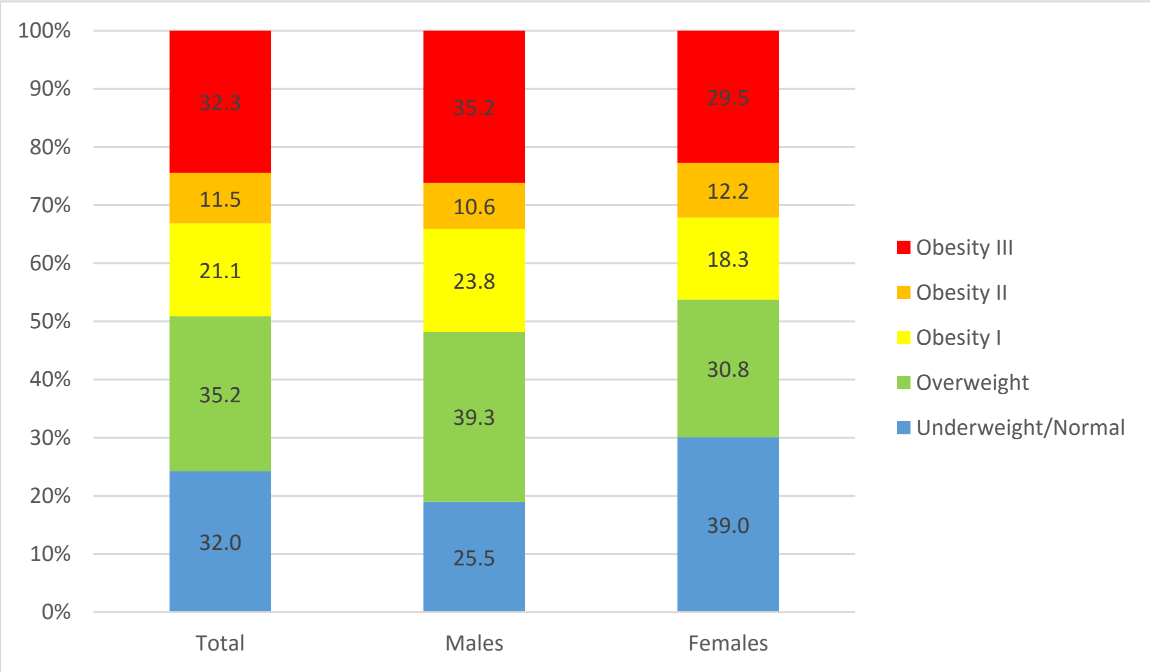


Figure 2. Body mass index, estimated proportion (%) of persons in Tasmania (adapted from the National Health Survey 2014–15 [17]).

Excess weight is a well-established risk factor for the development of type 2 diabetes, although the majority of obese people do not develop the disease [19]. Compared with normal weight adults, individuals with a BMI over 40 kg/m^2 have an odds ratio of 7.4 for a diagnosis of diabetes [20]. The risk of type 2 diabetes increases not only with increased body mass but also with increased adiposity of the upper body, as indicated by an increased waist-to-hip ratio [21]. At least three possible mechanisms have been suggested to link the predisposition of patients with obesity to type 2 diabetes through decreased insulin sensitivity: increased production of adipokines/cytokines (including tumour necrosis factor and interleukin-6), ectopic fat disposition in liver and muscles, and mitochondrial dysfunction [22-24].

Similar mechanisms also contribute to the development of cardiovascular diseases, making obesity an important cardiovascular risk factor [25]. In large sample populations, obesity was found to be associated with an increased risk of heart failure [26] and accelerated progression of atherosclerosis [27]. Increased adiposity has been established as an independent predictor of coronary heart disease, with a risk increase of 8% for each increment of BMI [28].

Increased adiposity is linked to cancer via three main factors: the insulin – IGF-1 axis, sex hormones and adipocyte-derived cytokines, with local metabolic alterations in adipose tissue provoking multiple systemic metabolic alterations and contributing to tumour development [29, 30]. A large population-based cohort study of more than five million UK adults found linear positive associations between BMI increase and cancers of the uterus, gallbladder, kidney, cervix, thyroid and leukaemia, along with a positive link between BMI and liver, colon, ovarian and post-menopausal breast cancers [31]. A meta-analysis involving more than 280,000 cancer cases revealed associations between BMI increase and malignant melanoma and rectal cancers in men, endometrial, gallbladder, postmenopausal breast and pancreatic cancers in women, and oesophageal adenocarcinoma, leukaemia, multiple myeloma, non-Hodgkin lymphoma, colon, thyroid and renal cancer in both sexes [32]. Pre-diagnosis BMI is an important independent preoperative factor of survival in non-metastatic colorectal cancer [33]. Increasing BMI in patients with rectal cancer is associated with a higher chance of local recurrence and decreased likelihood of sphincter preservation [34]. The risk of death also increases depending on BMI in stomach and prostate cancers in men and cancers of the breast, uterus, cervix and ovary in women, with estimated a contribution of overweight and obesity to cancer mortality of 14–20% [35].

Weight gain in adults is a strong and independent risk factor for premature death [36]. In a large pooled analysis of 20 studies, it was estimated that obesity was associated with significantly increased rates of mortality, mostly due to heart disease, cancer and diabetes, and the life expectancy of Class III obese individuals was substantially reduced compared with those of normal weight, with 6.5 years of life lost for BMI of 40–44.9 kg/m^2 up to 13.7 years for BMI of 55–59.9 kg/m^2 [37]. Although overall life expectancy did not appear to change in Class I (mild) obesity, disability-free life expectancy decreased by 2.7 years [38]; for all classes of obesity combined, disability-free life expectancy decreased by 4.5 years [39]. Given the high prevalence of obesity, it can have a nationwide effect, and obesity reduced the estimated life expectancy in the USA at age 50 years by 1.54 years [40].

1.1.4 Costs of obesity

In the United States, the direct medical costs of overweight and obesity are approximately 5 to 10% of healthcare spending in the USA [41]. When also accounting for comorbidity-related expenditure, annual spending in 2010 was estimated at $315.8 billion or 27.5% of total healthcare expenditures in the USA [42]. This was a significant increase from $78.5 billion in 1998 [43]. The costs of overweight and obesity were projected to reach $861 billion in 2030 [44].

The relationship between medical costs and BMI is J-shaped, with an exponential increase in costs in Class II and Class III obesity; the higher the BMI, the greater the cost reduction is in medical care associated with weight loss [42]. National cost estimates from the USA demonstrate significantly higher hospital costs for operative procedures as well as length of stay and an increased number of diagnostic and therapeutic procedures in obese patients compared with non-obese patients, despite equivalent postoperative complication rates [45].

In addition to direct healthcare costs, indirect costs due to lost productivity and early premature mortality are even higher than direct costs and contribute 54–59% to the total estimated costs [46]. Employees with a BMI over 30 kg/m^2 have the greatest short-term disability costs and days and lowest productivity [47]. The costs for short-term disability and worker's compensation claims were more than twice as high for morbidly obese employees [48].

The evidence from Australia shows that in the obese population aged 45 and over, compared with normal weight individuals, average annual health expenditures are estimated to be 19% higher for Class I obesity and 51% higher for Class II and Class III obesity, with significant differences in all types of care: emergency departments, inpatient hospital costs, outpatient costs and prescription drugs [49].

The total Australian direct costs of overweight and obesity in 2005 were estimated to be $21.0 billion, and the direct costs of obesity were estimated to be $8.3 billion. A significant burden was taken by the government, with average annual costs of subsidies for overweight and obesity of $3917 per person and a total cost of $35.6 billion per year [50]. Productivity loss costs were estimated at $637 million in 2005 [51] and $3.6 billion in 2008 [52]. The distribution of the burden of the financial costs in 2005 was 29.1% borne by individuals, 16.4% by family and friends, 37.0% by the federal government, 5.0% by state governments, 0.1% by employers and 12.4% by the rest of society [52].

1.2 Treatment of obesity

1.2.1 Diet and lifestyle modification

Diet and lifestyle modifications are the basis of all treatment guidelines and a part of multicomponent comprehensive intervention, with implementation of simultaneous strategies developed to change an individual's behaviour, reduce overall energy intake and increase energy expenses by promoting physical activity [3, 53, 54]. In a study of more than 5,000 overweight and obese adults with type 2 diabetes, intensive lifestyle interventions over the course of eight years in certain participants produced clinically meaningful weight loss, defined as 5% or more of body mass, and could be used to manage obesity and obesity-related conditions. However, this effect, including long-term weight maintenance, was observed only in half of participants [55]. The Diabetes Prevention Program demonstrated that despite weight regain in the lifestyle intervention population, the benefit in terms of reduction of type 2 diabetes incidence (prevention or delay of diabetes) still persisted for at least 10 years [56]. A systematic review showed that although absolute weight loss with intensive lifestyle intervention continuing for a year is modest and is on average 8 kg, it nevertheless translates into health benefits and improvements in blood pressure, lipid levels and glycaemic control [54]. Commercially available interventions with durations of up to one year produce an average weight loss of 3% [57].

Weight loss diets should provide less energy than is expended daily. The widespread belief in the existence of an ideal diet is not supported by the available literature, and large studies and meta-analyses have not found significant differences in weight loss among low-calorie diets composed of different nutritional proportions [58, 59]. Therefore, the main characteristic of the provided dietary intervention for weight loss should be ease of adherence [60]. However, diets can provide other benefits, and meta-analyses have found that Mediterranean diets are associated with cardiovascular risk reduction [61, 62].

Very low calorie diets (200–800 kcal/day) provide rapid initial weight loss; however, the long-term effects of these diets are not different from those of other dietary approaches, and therefore their recommendation should be limited to clinically necessary rapid weight loss, such as for preoperative preparation [53, 63].

Adding physical activity to dietary interventions can result in an additional 1–1.5 kg average weight loss over a 1-year period with general health benefits [53, 64], although the weight loss effect is not sustainable [55]. Table 1 summarises comprehensive lifestyle interventions [65].

Table 1. Elements of comprehensive lifestyle interventions for overweight and obesity (reproduced from Apovian et al., 2015 [65]).

Element	Recommendation
Reduced calorie diet	Multiple methods are effective: • Set a caloric goal (1,200–1,500 kcal/day for women, 1,500–1,800 kcal/day for men, adjusted for body weight) • Specify a caloric deficit (500 or 750 kcal/ day) • Restrict/reduce intake of certain food types (e.g., high-carbohydrate, low-fibre, or high-fat foods) to create energy deficit • Consider patient preferences and health status when identifying a diet–a variety of approaches can produce weight loss
Increased physical activity	Aerobic activity > 150 min/week for weight loss Resistance training to preserve lean mass 200–300 min/week aerobic activity to maintain weight loss
Behavioural intervention	Ideal: • Face-to-face sessions (≥ 14 with a trained interventionist over the first 6 months) • Maintain efforts over 1 year • Incorporate strategies such as goal-setting and self-monitoring Alternatives to face-to-face counselling: • Telephone or electronic counselling with a trained interventionist • Commercial weight loss programs • Tend to produce less weight loss than face-to-face counselling Maintenance: • Continued contact (once monthly) with a trained interventionist

1.2.2 Pharmacological treatment

Pharmacological treatment is the next stage in the step-wise approach to obesity treatment and is recommended if non-pharmacological treatment fails to achieve 5% weight loss of the initial body weight [53, 54, 66]. Pharmacological treatment is recommended by the Endocrine Society (USA) for overweight individuals with a BMI over 27 kg/m^2 and one or more obesity-related risk factors or for individuals with BMI over 30 kg/m^2 [65]. Five weight loss medications are currently approved in the USA for chronic weight management, three of those are approved in the European Union, three are approved in Australia, and one more is available for off-label use (Table 2) [60, 67].

Pharmacotherapy should be guided by three principles [66]. First, pharmacotherapy should not be the only intervention but accompany and reinforce lifestyle and dietary interventions. Second, patients and prescribers should be familiar with the side-effect profiles of the medications and understand their effects and expected effectiveness. Third, if clinically significant weight loss (defined as 5% of total body weight) has not been achieved within 3–4 months, a new treatment strategy should be implemented. Weight loss at this point is a predictor of weight loss over a long-term period [65].

When using pharmacological therapy, patients should be closely monitored for the first three months (or longer for medications with a gradual dose increase) to assess safety, tolerability and efficacy, and medication should be ceased or replaced in case any concerns arise [67].

Table 2. Medications for weight loss management (adapted from Bray, Ching Lee [60, 67])

Medication	Mechanism of action	Available			Mean percentage weight loss	Advantages	Disadvantages
		USA	European Union	Australia			
Phentermine	Sympathomimetic	Yes	No	Yes	Not stated	Inexpensive	Side-effect profile; no long-term data
Orlistat	Pancreatic lipase inhibitor	Yes	Yes	Yes	-6.1%	Not absorbed; long-term data	Modest weight loss; side-effect profile
Lorcaserin	5–HT2c serotonin agonist	Yes	No	No	-5.8%	Mild side-effects; long-term data	Expensive; modest weight loss
Phentermine/ topiramate	Sympathomimetic anticonvulsant	Yes	No	Off-label	-7.8–9.8%	Robust weight loss; long-term data	Expensive; teratogen
Naltrexone SR/ bupropion SR	Opioid receptor antagonist; dopamine and noradrenaline reuptake inhibitor	Yes	Yes	No	-5.4%	Reduced food craving; long-term data	Moderately expensive; side-effect profile
Liraglutide	GLP-1 receptor agonist	Yes	Yes	Yes	-7.4%	Side-effect profile; long-term data	Expensive; injectable

In addition to well-justified reasons for therapy cessation, it is not uncommon for effective pharmacological therapy to be discontinued despite a requirement to continue therapy to maintain the effect. Reasons for therapy discontinuation include costs, concerns about side effects and the perception that the medication is no longer required after some weight loss is achieved [68]. However, given that the current concept of obesity suggests that it is a chronic and relapsing disease, intervention should be continued even after target points are achieved, similar to blood pressure or diabetes control [67].

1.2.3 Bariatric surgery

Surgical treatment of obesity is considered the most effective treatment method with the best results in terms of weight loss and improvement or resolution of obesity-related comorbidities, regardless of the type of the surgical procedure used [69]. However, this effectiveness relates to modern procedures, and a range of procedures have been abandoned, although individuals who have undergone those procedures can still be encountered. Figure 3 demonstrates the evolution of bariatric procedures over time [70].

More than 50 years ago, a procedure of jejuno-ileal bypass was introduced to create malabsorption through the creation of artificial short gut syndrome, mostly in individuals with a BMI over 50. In this procedure, the proximal 35 cm of the jejunum was anastomosed to the distal ileum 10 cm from the ileocaecal valve [71]. The surgery resulted in diabetes improvement but was accompanied with a large number of side effects and complications, such as liver failure secondary to anaerobic bacterial translocation, hypoproteinaemia, steatorrhea, nephrolithiasis due to calcium binding to fatty acids, and increased oxalate absorption and abdominal bloating. Although the majority of the patients achieved their weight loss goals, the side-effects profile caused this operation to be replaced with safer procedures [72].

Different variants of gastroplasty were used to restrict the stomach volume and decrease food intake by creating a small gastric reservoir. Initially, the technique of horizontal gastroplasty was used; however, the reservoir and its outlet dilated quickly, and the restrictive effect disappeared [73]. In the most common variant of gastroplasty, a stapled channel was formed along the lesser curvature banded with a mesh or a band. Initially promising good weight loss results, this procedure had a high long-term complication rate due to obstruction, band erosion, and weight regain [74] and was eventually abandoned [71].

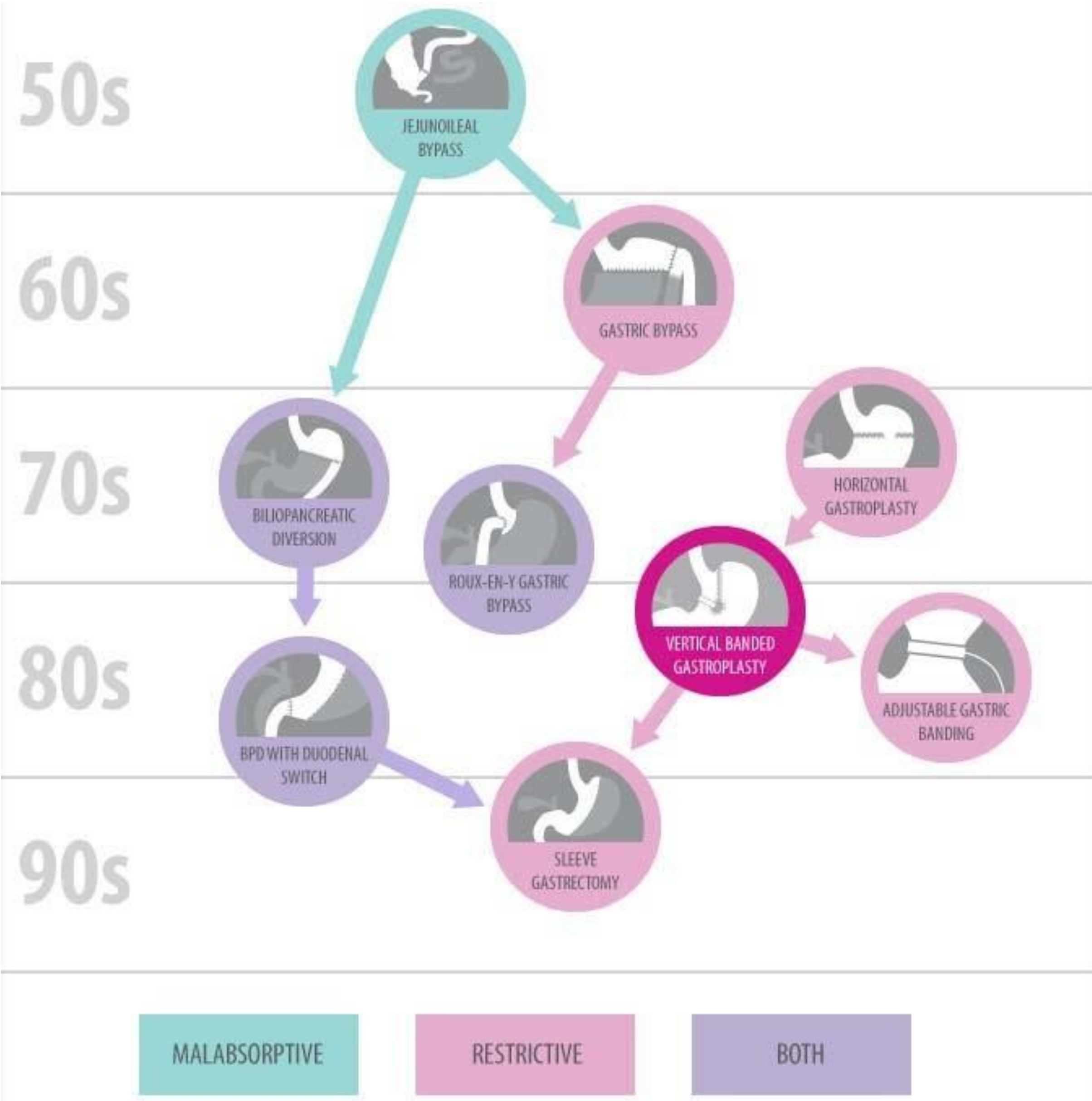


Figure 3. The evolution of bariatric surgery procedures from the 1950s to 1990s (reproduced from Arterburn et al., 2014 [70]).

1.2.3.1 Adjustable gastric banding

The first gastric band was described in 1978, and the first adjustable gastric band was used in 1985 [75, 76]. In the 1990s, adjustable gastric banding became a widely used procedure, performed mostly laparoscopically (LAGB), in which a band restricting food passage to the proximal stomach is placed. The restriction can be adjusted by filling a band with saline through a subcutaneous port connected to the band via a tubing system (Figure 4). Optimal restriction should reduce food intake, cause early satiety with a small food amount and not cause obstruction or dysphagia [77, 78].

A large meta-analysis of long-term follow-up studies demonstrated that the average percentage of excess weight loss 15 years post-surgery was 47.1% [79]. Revisions were performed in 50.4% of cases for the following reasons: pouch enlargement – 26.0%, band erosion – 3.4%, port/tubing problems – 21.0%, band explantations – 5.6%. It should be noted that revision rates decreased with the evolution of the technique. Certain studies provided even higher rates of band removals of up to 48.6–52.2%. Those studies also showed suboptimal satisfaction levels with the operation results (42–63%); a study examining long-term results in super-obese patients demonstrated that only 11% of patients with a BMI of 50 kg/m^2 or higher achieved and maintained weight loss of 50% over a 10-year period [80-82].

Worldwide, the LAGB procedure reached its peak in 2008, when it constituted 42.3% of all bariatric procedures. Since then, its popularity has declined, and in 2013, only 10% of bariatric procedures were performed as LAGB [83]. In the International Federation for Surgery for Obesity and Metabolic Diseases (IFSO) Global Registry of the total number of primary procedures performed in 2013–2017, only 6% were gastric bands [84]. Australian data show that in the financial year 2014/2015, 26.5% of registered procedures were LAGB, and this proportion decreased to 9.2% in 2016/2017 [85].

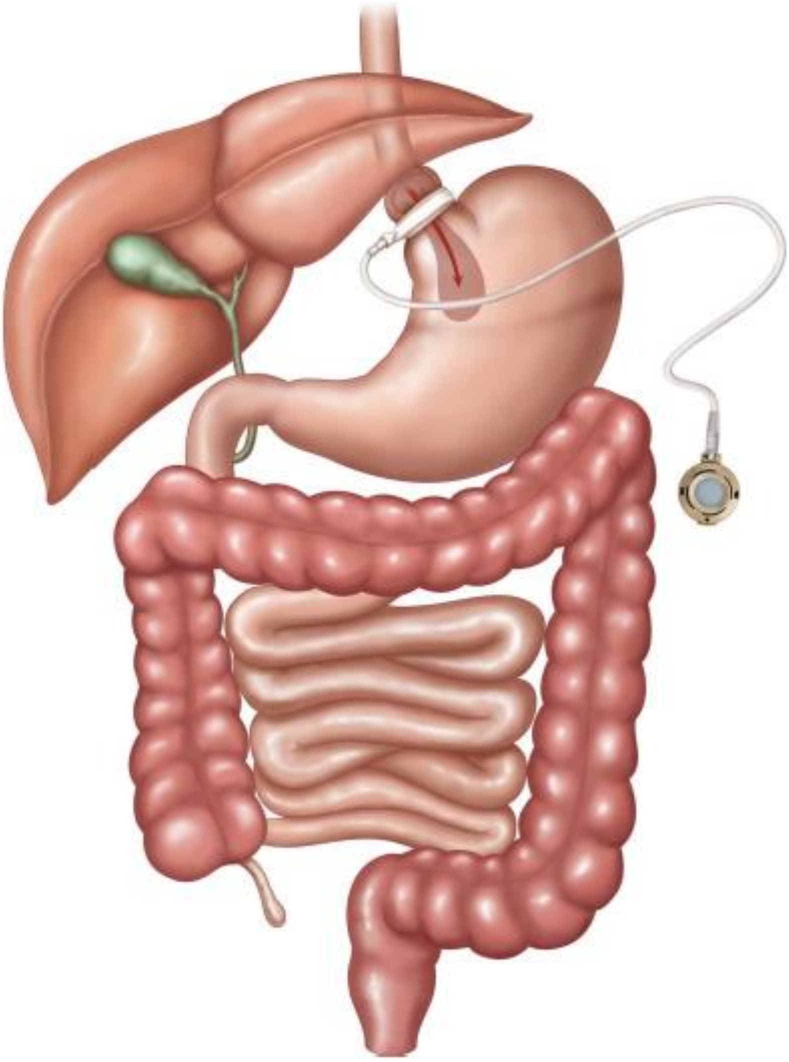


Figure 4. Adjustable gastric banding (reproduced from Neff et al. [86]).

1.2.3.2 Sleeve gastrectomy

Sleeve gastrectomy (SG) involves the creation of a narrow gastric sleeve using surgical staplers close to the lesser curvature and the removal of a significant portion of the stomach (Figure 5). Initially, SG was performed as the first stage of a two-stage duodenal switch (DS) procedure for patients with severe obesity and significant comorbidities, and SG started to be used as a stand-alone procedure in 2001, with the first results published in 2003 [87, 88].

The mechanism of action of this procedure cannot be explained purely by restriction due to stomach volume reduction. SG is accompanied by a significant decrease in ghrelin levels

[89] and an increase in the levels of GLP-1 and peptide-YY [90], thus providing an incretin effect similar to that observed after the gastric bypass procedure [91].

In the following two years, multiple studies demonstrated good short- and medium-term results, with average excess weight loss of 51% in the first 6 months and 63% in one year [92-97]. The proportion of SGs increased from 5.3% in 2008 to 37% in 2013 [83], thus becoming more popular than LAGB. SG constituted 43.6% of primary procedures in the IFSO Global Registry in 2013–2017 [84]. In the Australian Registry, its proportion increased from 49.1% in FY 2014/2015 to 65.3% in FY 2016/2017 [85]. This increase can be explained because the operative technique is relatively simple, does not involve the creation of anastomoses, and preserves physiological gastrointestinal continuity as well as the possibility of conversion to other types of bariatric procedure if required [98, 99].

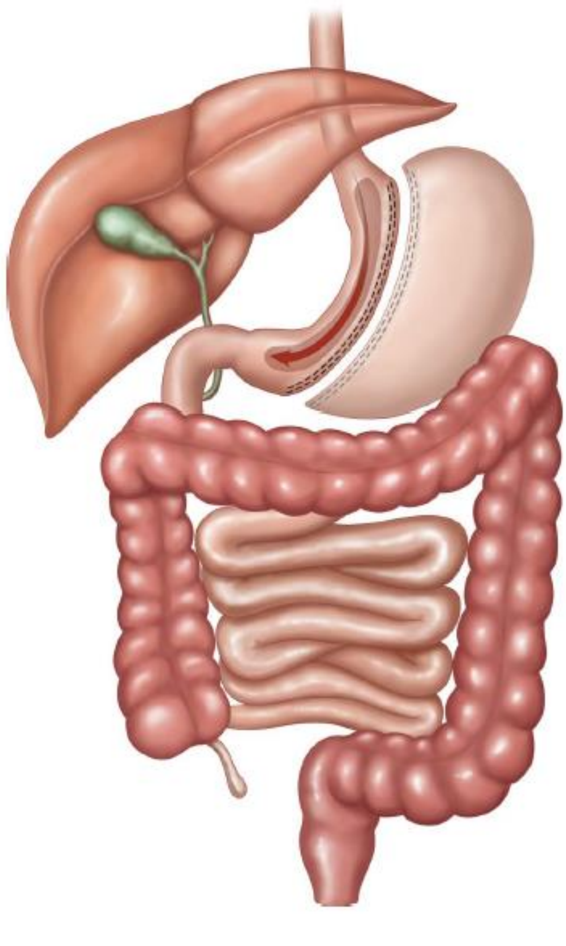


Figure 5. Sleeve gastrectomy (reproduced from Neff et al. [86]).

1.2.3.3 Gastric bypass

The procedure of Roux-en-Y gastric bypass (RYGB) combines malabsorptive and restrictive components by creating a small reservoir in the proximal stomach, which is anastomosed with the distal jejunum (Figure 6). The length of loops and types of anastomoses vary greatly [100-103].

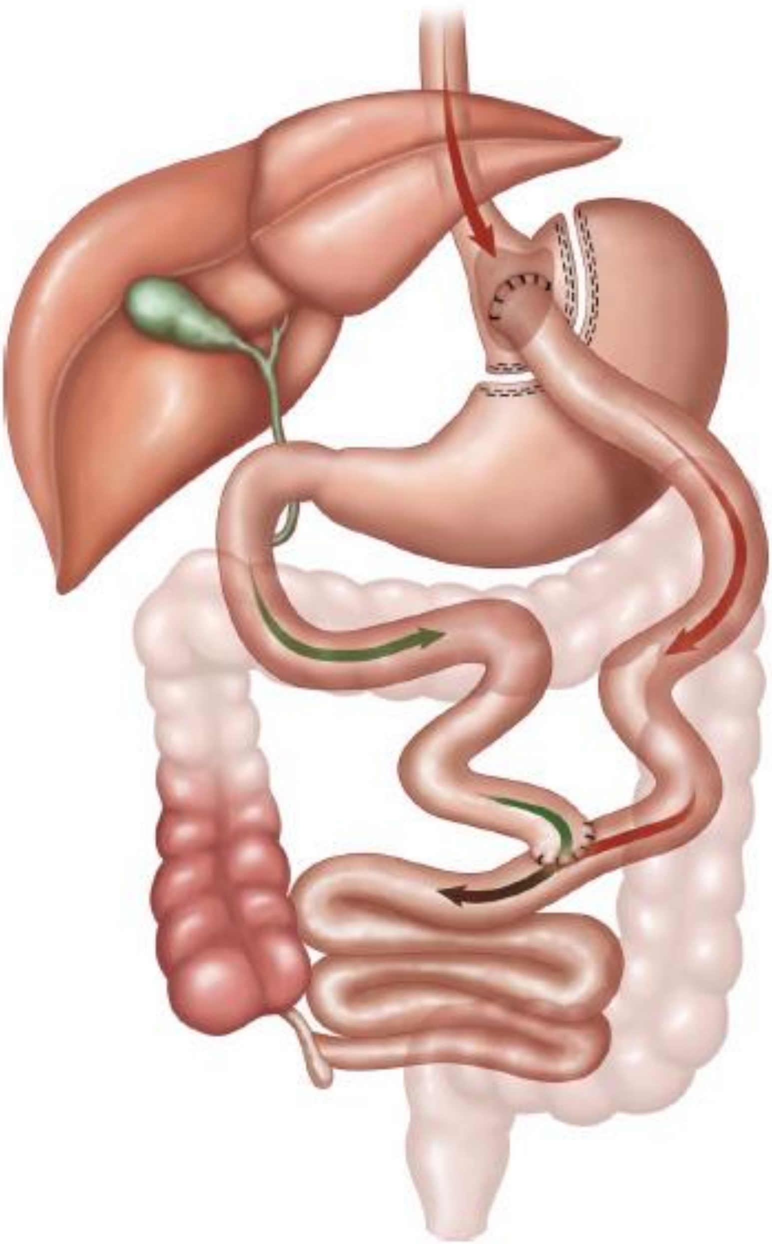


Figure 6. Roux-en-Y gastric bypass (reproduced from Neff et al. [86]).

One of the mechanisms of action in this operation is the incretin effect caused by early food passage to the midgut [104]. It also modifies food behaviour by decreasing the reward value of sweet and fatty food [105] as well forcing a decrease in high carbohydrate food consumption due to high rates (10%–21%) of dumping syndrome [106]. The procedure has good and sustainable weight loss results in the long-term period, with weight loss of over 60% according to some studies [107, 108].

This procedure has a relatively high long-term complication rate due to complications specific to this procedure, such as internal hernias (1–9%) [109-112], anastomotic strictures (3%–23%) [113, 114], marginal ulcers (1%–16%) [115, 116], gastro-gastric fistulas (1.5–6%) [117, 118], and anaemia due to iron or folic acid deficiency (20–49%) [119, 120].

This is one of the oldest procedures and has been performed since the 1970s. It remains the most commonly performed bariatric procedure in the world, but its proportion among other procedures decreased from 65% in 2003 to 45% in 2013 as SG increased in popularity [83]. In the IFSO Global Registry, 46.3% of primary procedures are different modifications of gastric bypass [84]. In the Australian Registry, the proportion of RYGB has remained stable at approximately 10% over the years [85].

1.2.3.4 Biliopancreatic diversion and duodenal switch

Biliopancreatic diversion (BPD) and duodenal switch (DS) procedures are performed as resection of a portion of the stomach (distal gastrectomy in BPD and sleeve gastrectomy in DS), with division of the gastrointestinal tract into alimentary and biliopancreatic channels and a short common loop where digestion and absorption occur (Figure 7).

These procedures are very effective in patients with a BMI of over 50 kg/m^2, with excess weight loss over 70% [87, 121-123]. For patients with initial a BMI of 40 to 50 kg/m^2, excess weight loss was 82% one year after surgery and 96% 18 months post-surgery [124, 125].

In the series of patients with a BMI of less than 40 kg/m^2, excess weight loss was over 100% [125, 126].

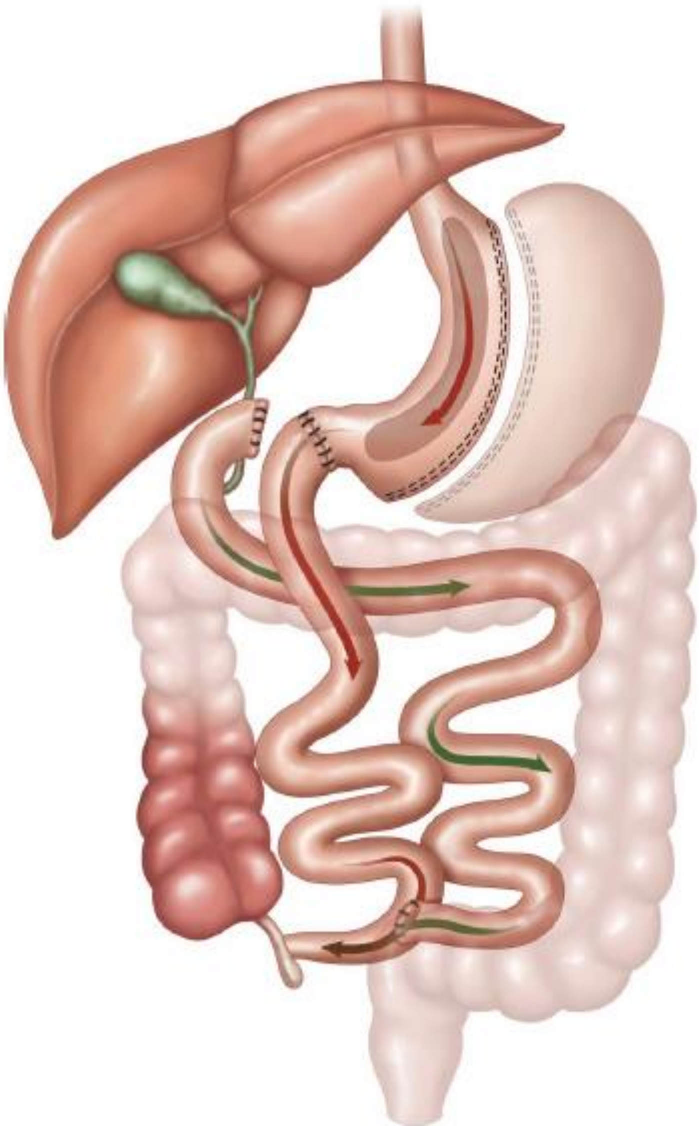


Figure 7. Biliopancreatic diversion (duodenal switch) (reproduced from Neff et al. [86]).

The complication rate, however, is very high and was at least 10% in the reports with the lowest rates [123] and 15–20% on average in other series [121, 127]. Among short-term complications, the most common were intra-abdominal bleeding (2.4–3.4%) [122, 128], intra-abdominal abscesses (up to 5.0%) [122], and duodeno-ileal anastomotic leaks in DS (1.0–1.9%), which are the main cause of mortality in these operations [121, 123, 127].

Long-term complications include nutritional deficiencies and severe malabsorption, with a rate of revisional operations for these reasons of up to 0.1% annually [121].

These procedures are not common and constitute only 1.5% of bariatric procedures worldwide [83]. Due to the technical complexity of those procedures, 8% are performed laparoscopically [107]. BPD and DS are not reported to be performed in Australia.

1.2.3.5 Indications and eligibility for bariatric surgery

The International Federation for the Surgery of Obesity - European Chapter (IFSO-EC) and European Association for the Study of Obesity (EASO) produced guidelines [129] recommending bariatric surgery for individuals aged from 18 to 60 years with a BMI over 40 kg/m^2 or for persons with a BMI of 35–40 kg/m^2 with comorbidities for which surgically induced weight loss is expected to improve the disorder (such as metabolic disorders, cardiorespiratory disease, severe joint disease, and obesity-related severe psychological problems). The BMI criterion used may be either current BMI or previous maximum attained BMI, implying that weight loss because of intensive treatment is not a contraindication to planned bariatric surgery and that weight regain after a substantial weight loss can be an indication for surgery. There are also special categories of patients for whom bariatric surgery should be considered by taking the individual situation into account, namely, patients with BMI of 30–35 kg/m^2 with type 2 diabetes, patients aged over 60, and adolescents with BMI over 40 kg/m^2 with at least one comorbidity who demonstrate maturity and adherence to a weight loss program.

The European guidelines also specifically mention contraindications to bariatric surgery: absence of a period of medical management, inability to participate in follow-up, non-stabilised mental disorders, alcohol or drug abuse, diseases threatening life in the short-term, and inability to care for themselves with a lack of support.

Based on the categories of patients who benefit the most from bariatric surgery, the Australian National Health and Research Council guidelines recommend bariatric surgery for adults with a BMI over 40 kg/m^2; for adults with a BMI over 35 kg/m^2 and comorbidities that may improve with weight loss, bariatric surgery may be considered, taking into account the individual situation. Bariatric surgery may be a consideration for people with a BMI > 30 kg/m^2 who have poorly controlled type 2 diabetes and are at increased cardiovascular risk, taking into account the individual situation [2].

We estimated that the number of Australians eligible for bariatric surgery according to these guidelines was more than 800,000 in 2011–2013, with nearly 400,000 having Class III obesity. Of that population, 46% did not have private health insurance, making this a problem of great significance for public healthcare [130]. Despite the potential demand for public bariatric surgery, not all Australian states and territories have guidelines and policies for bariatric surgery, and five states and territories with those guidelines have significant variations and lack full consistency with the national guidelines. The guidance for prioritising patients is quite limited [131].

1.2.3.6 Revisional bariatric surgery

While bariatric surgery is the most effective modality of treatment for severe obesity and its comorbidities, the success rate is not 100%, and subsequent revisional surgeries are occasionally required for undesirable results of the initial operation. The current paradigm of revisional bariatric surgery views obesity as a chronic disease that, like other chronic diseases, will have long-term failures with any treatment modality and require treatment escalation in some patients [132, 133].

Revisional bariatric surgery has a well-established, short-term complication rate that is higher than those for similar primary procedures but is considered acceptable by surgeons [134, 135].

The two most common reasons for revisional surgery are weight loss failure (either as insufficient weight loss or weight recidivism after initially successful results) and complications of the initial surgery [133]. Revisional surgery for complications aims to correct the specific complication and is usually tailored to it. Revisional surgery for obesity management failure provides more options for the surgeon: it can be directed to the specific cause of unsuccessful weight loss (such as LAGB replacement for its malfunction or narrowing a wide gastro-jejunal anastomosis in RYGB), or one procedure can be converted into another, such as the anatomy of sleeve gastrectomy can be transformed into RYGB. Multiple types of revisions have been described depending on the primary procedure, including procedures that were abandoned during the evolution of bariatric surgery; however, patients with anatomy altered by those procedures may still be encountered in bariatric practice [132].

1.2.3.7 Bariatric surgery in Australia

The majority of available data on bariatric surgery performed in Australia comes from Australian Institute of Health and Welfare (AIHW) reports and from the Bariatric Surgery Registry (BSR) [85, 136].

Overall, the number of bariatric procedures has increased over time, with 9,300 weight loss surgeries performed in 2005–2006 and 22,700 in 2014–2015. Bariatric surgery in Australia is performed in both public and private systems, with the majority (89%) of procedures being performed in private systems. More than one-third of the public procedures are reported to be performed in Victorian hospitals. Tasmania had the highest number of public bariatric procedures per capita nationally in 2014–2015, with 2.7 procedures per 10,000 population (Figure 8).

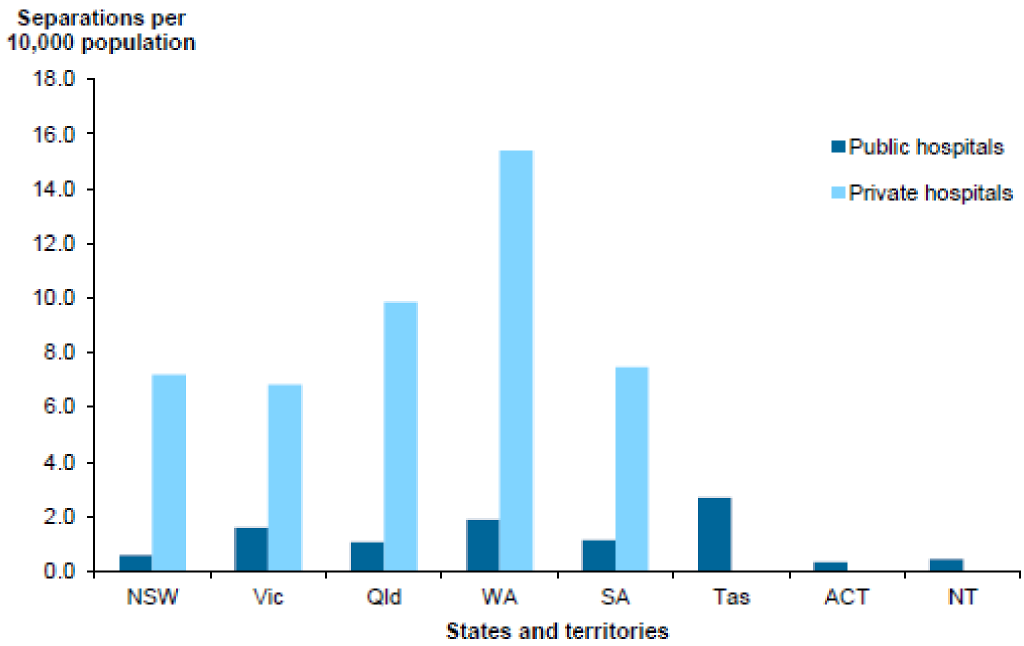
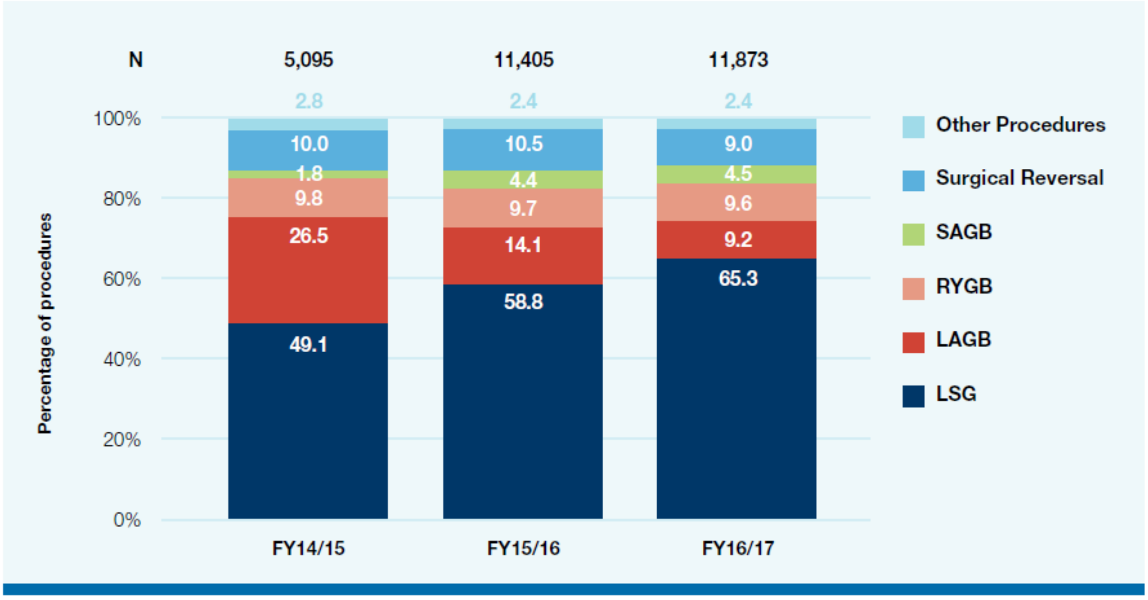


Figure 8. Separation rates (per 10,000 population) for weight loss surgery by public and private hospitals, states and territories in Australia, 2014–15 (reproduced from Australian Institute of Health and Welfare report, 2017 [136]; no data on Tasmanian private hospitals were available in the report).

Although Classes 2 and 3 of obesity are somewhat more prevalent in Australian females, there is a marked disproportion in the sex of bariatric surgery patients, and 79.1% of bariatric surgery recipients are females [136].

There have been changes in the proportions of different types of bariatric procedures performed in Australia. In 2011, Australia was the only reported country in which the majority of bariatric procedures were adjustable gastric banding (7,200 out of 12,000, or 60%) [137]. By 2013, the situation had changed, and the proportion of adjustable gastric banding dropped to 30%, with sleeve gastrectomy representing more than 60% of bariatric procedures [83]. The BSR, despite not capturing all procedures, demonstrates similar trends in terms of the decline in adjustable gastric banding and increase in sleeve gastrectomy (Figure 9).



Notes: N = number of procedures. Abandoned procedures are excluded

Figure 9. Changes in procedure type captured by the BSR (SAGB – single anastomosis gastric bypass; RYGB – Roux-en-Y gastric bypass; LAGB – laparoscopic adjustable gastric banding; LSG – laparoscopic sleeve gastrectomy) (reproduced from the Fifth Annual Report of the Bariatric Surgery Registry, 2017 [85]).

Revisional bariatric surgery trends have changed over time, especially in the public sector. According to the AIHW report, the proportion of revisional procedure separations in the public sector increased from 19.5% in 2005–2006 to 36.7%, whereas revisions in the private sector decreased [136].

The increasing number of procedures performed, especially with the increase in more complex revisional procedures and the shift to the public sector, requires further investigation of hospital service use by bariatric patients, both primary and revisional. In particular, studies are needed in areas not mentioned or surveyed in the reports, such as determining and describing patient pathways to understand the relationships between primary surgical procedures and subsequent revisions [136].

1.3 Summary and research aims

Obesity is a significant problem, with the majority of adult Australians being overweight or obese. The association of obesity with multiple comorbidities, particularly type 2 diabetes, is well established. The burden of obesity and obesity-related comorbidities has a significant economic impact and reduces quality of life and life expectancy.

Among multiple treatment modalities for obesity, bariatric surgery is currently the most effective and has long-term effects. Bariatric surgery is included in different national and international guidelines, and in many countries, including Australia, it is performed in the public sector. Revisional bariatric surgery is not uncommon and has shifted towards the public sector compared with privately performed surgeries. According to an Australian Institute of Health and Welfare report, in 2014–2015, 37% of bariatric procedures performed in public hospitals were revisional in comparison with the 18% of bariatric operations in private hospitals [138].

In the setting of substantially greater demand for bariatric surgery than supply, such as in Tasmania, the impact of bariatric surgery on health service use should be investigated to allow better planning of health services provision.

The aims of this PhD thesis were as follows:

1. Evaluate public hospital service use by all bariatric patients wait-listed for primary public bariatric surgery in Tasmania by investigating and describing public hospital admissions (Chapter 2) and emergency department (ED) presentations (Chapter 3) before wait-list placement, while waiting, and after removal from the wait-list.
2. Describe patient pathways and evaluate the need for subsequent revisions and reoperations for short- and long-term complications after a secondary (first revision) bariatric surgery through a systematic review of the literature (Chapter 4).

3. Assess the demand for revisional bariatric surgery in the Tasmanian public sector and evaluate the accessibility of publicly funded bariatric surgery and the use of public hospital services for patients wait-listed for revisional vs primary bariatric surgery (Chapter 5).

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Chapter 2: Public hospital admissions for patients wait-listed for public bariatric surgery in Tasmania, Australia: a statewide cohort study

Abstract

Background: Increased demand for public bariatric surgery can create prolonged wait-list times and may increase the burden on public healthcare. The long-term influence of bariatric surgery on hospital admissions is under-investigated.

Aims: To determine public hospital service use in the form of hospital admissions and days in hospital per year in patients wait-listed for bariatric surgery before and after surgery or wait-list removal.

Methods: All Tasmanians waiting for publicly funded primary bariatric surgery from 2008 to 2013 and their hospital admissions between 2006 and 2014 were identified and data extracted using administrative datasets and medical records. Admissions were assigned to three periods: before wait-list, while waiting, and after a bariatric operation or drop-out. A negative binomial regression mixed effect model was used to compare incidence rate ratios (IRR) of hospital admissions and days in hospital per year during different observation periods and across patient groups (operated, dropped-out and waiting), adjusting for age, sex and non-independent observation periods.

Results: 652 patients had 2,541 public hospital admission events. 178 patients had publicly funded laparoscopic adjustable gastric banding (LAGB), and 236 patients were removed from the wait-list without surgery. Dropped-out patients were on average older at wait-list placement (46.6±12.6 years) than the operated group (42.9±11.1), $p<0.05$ and had more days in hospital per year (IRR 2.22, 95% CI 1.36–3.61) while on the wait-list. Hospital admission rates did not increase post-surgery (IRR 1.08, 95% CI 0.83–1.41) but days admitted per year did increase (IRR 1.53, 95% CI 1.01–2.34).

Conclusions: Among patients wait-listed for publicly funded bariatric surgery in Tasmania, those who were younger and had fewer days in hospital per year were more likely to have publicly funded LAGB surgery than those who dropped-out of the wait-list. Whilst LAGB surgery has many health benefits, it was associated with more days in hospital per year and not associated with fewer public hospital admissions in the first three years of follow-up.

2.1 Introduction

Overweight and obesity affect approximately 63% of Australian adults [1]. Over 800,000 (26% of adults) are potentially eligible for bariatric surgery according to existing national guidelines based on body mass index (BMI) and comorbidities [2, 3]. Australia has universal healthcare (Medicare) that subsidises health costs for all citizens and permanent residents and provides free treatment in public hospitals. Private healthcare co-exists with the public system and is accessed by individuals with private health insurance or who self-fund. In some instances, patients may access both the public and private systems in the course of receiving treatment. More than 50% of all surgical procedures in Australia are performed in the private sector, with significantly shorter waiting times than in the public system [4]. Bariatric surgery in Australia is performed in both the public and private systems, although the majority of primary procedures are performed in private hospitals (92% of those captured in the BSR) [5], with waiting times of typically weeks or months rather than years. We have previously estimated that 46% of those eligible for bariatric surgery in Australia do not have private insurance [3], highlighting the potential unmet demand for publicly funded surgery.

In Australia, it is recommended that public patients wait no longer than one year for elective surgery [6]. However, Tasmania has had high proportions of patients waiting for longer than one year in the public system (8.7%–15.5% for all types of elective surgical procedures compared with 1.8%–3.4% for the whole of Australia in 2008–2016 [6, 7] and 78.3% for bariatric surgery in 2016 [8]). When demand exceeds the capacity to provide bariatric surgery, patients may experience long wait times, and some patients may even die before receiving surgery [9, 10].

Few studies have investigated the influence of prolonged wait-list times on comorbidities and patients' well-being, with most studies coming from Canada [10-13]. When surveyed, wait-listed patients state that with prolonged wait times their physical symptoms worsen, and they gain weight and find the experience of waiting emotionally difficult [12, 14]. Patient drop-out from non-compliance with bariatric surgery program requirements and self-removal from programs also increase with waiting time [15]. The studies, however, focussed on the negative impact of prolonged waiting times on patients, leaving a gap in understanding of the impact on public health service use.

The Australian experience shows that obesity is associated with higher consumption of health services and expenditures. For patients with a BMI over 35, health expenditures are, on average, 51% higher than for those of normal weight, with costs elevated for all types of medical care (inpatient, emergency and outpatient) and a higher probability of having any expenditure in inpatient and emergency settings in both the public and private systems [16]. Despite the different approaches to economic evaluations [17], there is evidence that bariatric surgery can result in life-long cost-savings [18-20], indicating that delaying surgery could possibly decrease savings and quality-adjusted life-year benefits. Moreover, for certain conditions, such as type 2 diabetes mellitus (T2DM), early bariatric surgery brings greater health benefits than when surgery is delayed [21]. However, even if bariatric surgery can produce savings for the healthcare system in the long run, it does not necessarily reduce the burden for public healthcare, as rates of hospital admissions after bariatric surgery can increase, especially for acute presentations relating to surgical complications, conditions linked to severe obesity such as gallstones, or alcohol and substance abuse [22]. Admissions for reasons such as total joint arthroplasty may increase after bariatric surgery as patients lose weight and are considered more suitable candidates [23].

Besides costs, public hospital service use directly influences hospital capacity, which when strained and overcrowded is associated with poor health outcomes and increased mortality [24, 25]. Overall, the impact of bariatric surgery on public hospital service use and hospital admissions in particular is not clear in the long term. Patients also consume healthcare resources while on the wait-list, and little is known about what happens to patients who are removed from the wait-lists without receiving bariatric surgery.

In this retrospective statewide cohort study, we aimed to evaluate public hospital service use by all bariatric patients wait-listed for primary public bariatric surgery in Tasmania through an investigation and description of public hospital admissions before wait-list placement, while waiting, and after removal from the wait-list. Patients were classified according to their wait-list status at the end of the study period, i.e., operated, dropped-out or waiting. It was hypothesised that (a) beyond the immediate postoperative period, those undergoing public bariatric surgery would have lower rates of public hospital admissions and lower rates of days admitted than before surgery as their health improved; and (b) patients wait-listed for public bariatric surgery but not receiving it (dropped-out from the wait-list) would have increasing rates of public hospital admissions over time.

2.2 Materials and methods

This is a retrospective statewide cohort study of all patients who were on the public bariatric surgery wait-list in Tasmania from January 1, 2008 to December 31, 2013 to determine rates of public hospital admissions prior to being placed on the wait-list, while patients were waiting for surgery, and after surgery or drop-out of the waiting list. Admissions were ascertained from administrative data with look-back to May 1, 2006 and follow-up to December 31, 2014, or date of death, whichever was soonest. Patients were referred for bariatric surgery following unsuccessful management of obesity and related comorbidities and placed on the wait-list after a surgical consultation. During the study period, there were no mandatory preoperative weight loss requirements or bariatric-surgery preparation after being placed on the wait-list, and once on the wait-list, patients were considered ready for surgery.

All patients appearing on the public wait-list for bariatric surgery in Tasmania during 2008–2013 were identified using three administrative databases kept by the state government's Department of Health and Human Services to manage public wait-lists; it was not a single database due to system upgrades and re-organisation in the state health services over the sampling period. Wait-listed patients were recorded at discrete time-points (census dates), at which time the wait-lists were updated, and patients were either removed or retained. There was no period with more than three months between census points, which ensured that patients wait-listed and operated in the same year were not lost for sampling. Lists were updated with removal of patients who had received surgery in the public system, who the surgeon deemed ineligible, or who elected to be withdrawn (including a possibility of being already operated in the private sector). Letters were sent to wait-list patients annually to determine whether or not they wished to remain on the wait-list. Patients who were no longer contactable were also removed from the wait-list. In total 776 patients placed on the wait-list for bariatric surgery were identified during the selected period.

Hospital admission details for all inpatient facilities in the state during the 2006–2014 period were extracted from administrative databases for all identified patients. To ensure the quality of data, additional manual data extraction from the hospital digital medical records was performed for all hospital admissions and verified against the administrative database entries. This identified four placements that were not for bariatric surgery and 25 out of the study period due to coding errors in the original databases. Hospital admission notes were checked for operation details, and 95 patients who had revisional bariatric surgery following their first wait-list entry were excluded, leaving 652 patients (Figure 10). In total 5820 admission records for

652 patients were identified, of which 2700 same-day admissions for haemodialysis were excluded as they belonged to a single patient, skewing data significantly.

According to their wait-list status at the end of the study period, patients were classified as operated, dropped-out or waiting. The dropped-out group included those who were removed from the wait-list by the surgeon, and those who elected to be removed, were not contactable or died. Patients who died before the end of 2014 were followed up to their date of death within their allocated group (operated or dropped-out). For patients who disappeared from the wait-list but were not actively removed, only waiting periods prior to the last census date were included in the analysis to ensure the validity of the observation period.

Three periods were identified during 2006–2014: (1) prior to being placed on the wait-list (pre-wait-list), (2) while on the wait-list for the primary procedure, and (3) no longer waiting following a primary procedure or through removal from the wait-list (post-wait-list). All patients were observed from May 1, 2006 to December 31, 2014 or until death, whichever came first. Additionally, all wait-listed patients were linked to Tasmanian death registrations to ensure the validity of observation dates.

Data on the wait-list entries included date of placement, date of removal and removal reason. Data on hospital admissions included dates of admission and discharge, anthropometric data (where available), hospital, unit, ICD-10AM primary diagnosis, ICD-10AM procedures, Australian-refined diagnosis related group (ARDRG) and major diagnostic category (MDC).

Where available, anthropometric data were extracted from medical records, however, record keeping was suboptimal and too few extracted values did not allow us to perform analysis of weight and BMI changes over time.

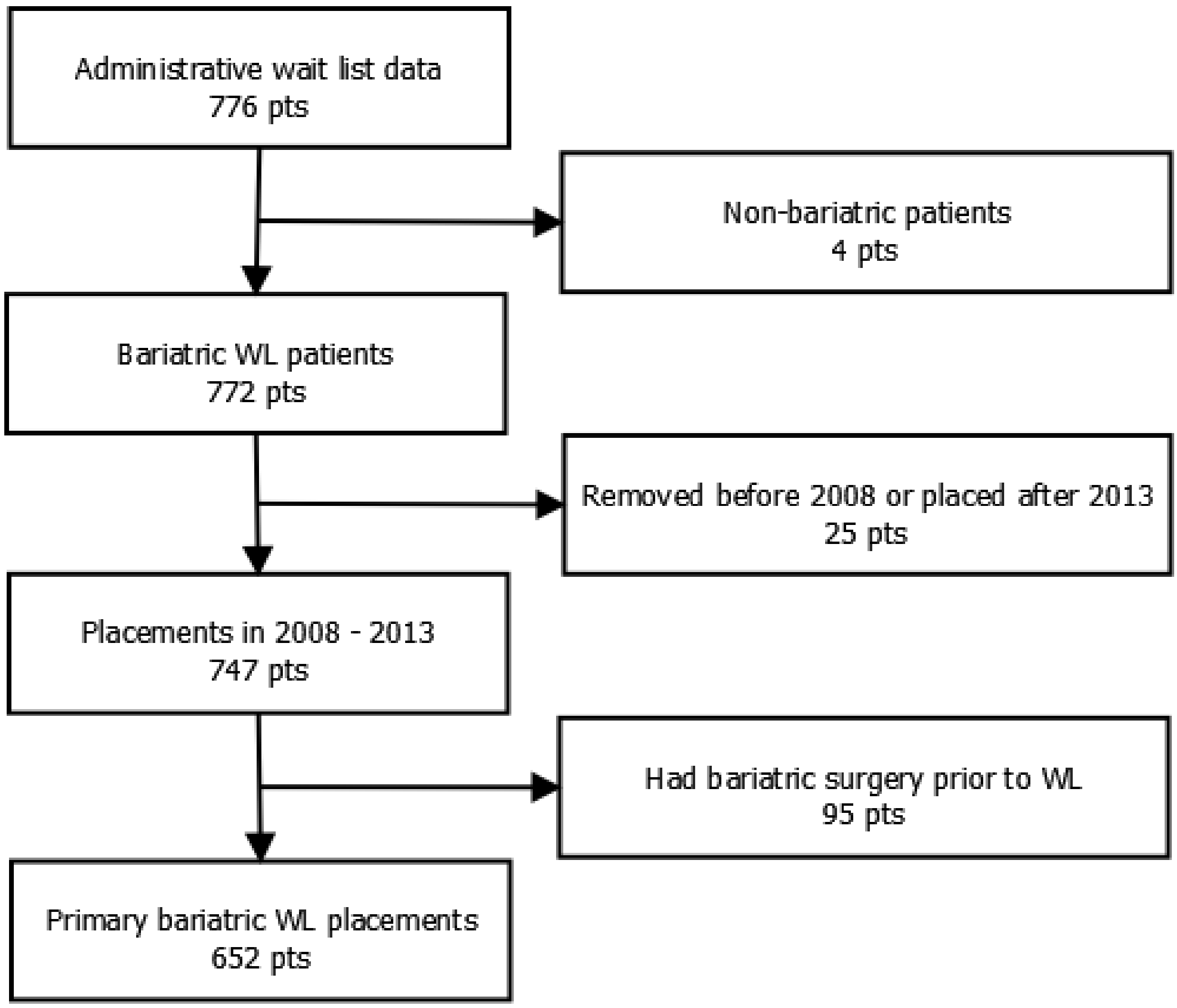

Figure 10. Patient selection flowchart

When calculating admission rates and lengths of stay, primary bariatric procedures were excluded, as well as admissions for cancelled or postponed bariatric procedures. Interfacility transfers were counted as single admissions. Total admission rates were calculated including observation time of persons without any admissions during the study period. Observation time for admission rates did not include in-patient time, as patients were not at risk for admission while being in-patients. When calculating number of days in hospital to an observation period, if a patient was placed on the wait-list or removed from it while being admitted, all in-hospitals days were attributed to the earlier observation period whichever was earlier.

A negative binomial mixed-effect regression model of hospital admissions and lengths of stay was used to compare differences between study periods and patient groups. A mixed-effect model with a random intercept for participant was applied because the study periods were not independent. Incidence rate ratios (IRR) with 95% confidence intervals (CI) were estimated by including an offset in the model – log of days at risk for each period – and the model was adjusted for sex and age at the beginning of each period. Model fit was ensured with deviance residuals check. Adjusted incidence rate ratios were compared between periods with the wait-list period used as reference, and between groups with the operated group as reference.

Differences between patient characteristics were compared using the t-test and the χ^2 test. P-values less than 0.05 were considered statistically significant. Statistical analysis was performed using Stata 14.2 software.

2.3 Results

2.3.1 Patient characteristics

Of the 652 patients included in the study, 342 had already been on the wait-list prior to 2008. By the end of the study period, 178 (27.3%) were operated on, 236 (36.2%) were removed from the wait-list without operation (dropped-out).

For 109 of 178 operated-on patients, details on the type of surgery performed were extracted from the medical records; all had laparoscopic adjustable gastric banding (LAGB). The remainder of the procedures were outsourced to private hospitals (although funded by the public system), and the surgery type was not recorded in the health department’s database. However, all the outsourced procedures were performed by a single surgeon, who confirmed that LAGB was the only type of procedure performed for publicly funded patients.

Patient groups did not differ by sex and Aboriginal status. Average age at wait-list placement was younger in the operated than the dropped-out group (42.9 vs 46.6 years, p<0.05). The mean total observation period was 8.6±0.4 years for the operated group and 8.2±1.3 years for the dropped-out group (p<0.001). Mean follow-up time after removal from the wait-list was 3.1±1.8 years for operated-on patients (i.e., post-op period) and 2.5±1.3 years for dropped-out patients (p<0.001). The patient characteristics are presented in Table 3.

Table 3. Patient characteristics (statistically significant differences are highlighted in bold).

	Operated* (n = 178)	Dropped-out† (n = 236)	Waiting‡ (n = 238)	Total (n=652)
Age at time of wait-list (WL) placement, years (SD)	**42.9 ± 11.1**	**46.6 ± 12.6**	43.9±12.0	44.6±12.1
Males, % (n)	24 (43/178)	31 (73/236)	26 (62/238)	27 (178/652)
Aboriginal or Torres Strait Islander origin, % (n)	6.3 (9/143)	10.6 (23/217)	6.5 (8/124)	7.4 (40/484)
Weight at time of WL placement (n), kg	125.1±29.7 (25)	122.1±19.5 (29)	137.6±36.8 (29)	128.4±30.0 (83)
BMI at time of WL placement (n)	44.0±7.6 (16)	45.3±6.8 (16)	45.6±8.8 (19)	45.0±7.7 (51)
Weight at time of WL removal (n), kg	**139.8±29.8 (89)**	**118.1±25.5 (39)**	n/a	133.2±30.2 (128)
BMI at time of WL removal (n)	**49.6±9.4 (89)**	**44.1±8.6 (22)**	n/a	48.6±9.4 (111)
Average waiting time, years	4.1±2.8	4.5±2.4	4.4±2.6	4.4±2.6
Observation time prior to WL placement, years	2.6±1.8	2.5±1.6	2.6±1.9	1.9±1.9
Observation time during WL period, years	**3.5±2.1**	**4.0±1.9**	4.0±2.6	3.9±2.2
Observation time after removal from WL, years	**3.1±1.8**	**2.5±1.3**	n/a	2.7±1.7
Total observation time, years	**8.6±0.4**	**8.2±1.3**	6.1±3.0	7.5±2.3

* Patients who had bariatric surgery.
† Patients removed from the wait-list without operation.
‡ Patients remaining on the wait-list at the end of the study period. Those with the unknown status accounted only for their known waiting time

After excluding admissions for bariatric surgery and dealing with interfacility transfers, 2,541 admission events were analysed.

2.3.2 Hospital admission rates

Prior to being placed on the wait-list, the overall rate of hospital admissions was 49.0 per 100 person-years: 42.5 in the operated group and 56.3 in the dropped-out group. While on the wait-list, overall admission rates were similar to those observed for patients prior to their wait-list placement (42.7 and 58.6 admissions per 100 person-years for operated and dropped-out group respectively). After surgery the unadjusted admission rate increased to 61.6 per 100 person-years, while after drop-out from the wait-list it remained at the level 58.5 admissions per 100 person-years. Unadjusted hospital admission rates are summarised in Table 4.

When comparing IRR adjusted for age, sex and non-independent observation periods within participants, there was no significant difference between groups and periods (

Table 5).

Figure 11 demonstrates yearly changes in admission rates in relation to the wait-list removal date. An initial increase in admission rates post-surgery can be seen with a peak in the second year, and subsequent decrease in the third year (IRR between the third and the second year 0.61, 95% CI 0.38–0.98).

Table 4. Public hospital admission rates (unadjusted) per 100 person-years

Wait-list status	Pre wait-list	On wait-list	Post wait-list	Total
Operated	42.5	42.7	61.6	49.6
Dropped-out	56.3	58.6	58.5	58.0
Waiting/Unknown	46.8	45.6	n/a	46.0
Total	49.2	49.7	60.1	51.9

Table 5. Adjusted* public hospital admission incidence rate ratios (IRR) with 95% confidence intervals

Wait-list status	Period		
	Pre wait-list	On wait-list	Post wait-list
	IRR between groups		
Operated	1	1	1
Dropped-out	1.01 (0.86–1.49)	1.26 (0.92–1.72)	1.07 (0.78–1.50)
Waiting	0.88 (0.59–1.31)	1.02 (0.74–1.40)	n/a
	IRR between periods		
Operated	0.98 (0.71–1.34)	1	1.08 (0.83–1.41)
Dropped-out	0.78 (0.61–1.01)	1	0.96 (0.77–1.20)
Waiting	0.93 (0.73–1.17)	1	n/a

*Adjusted for age, sex and non-independent observation periods.

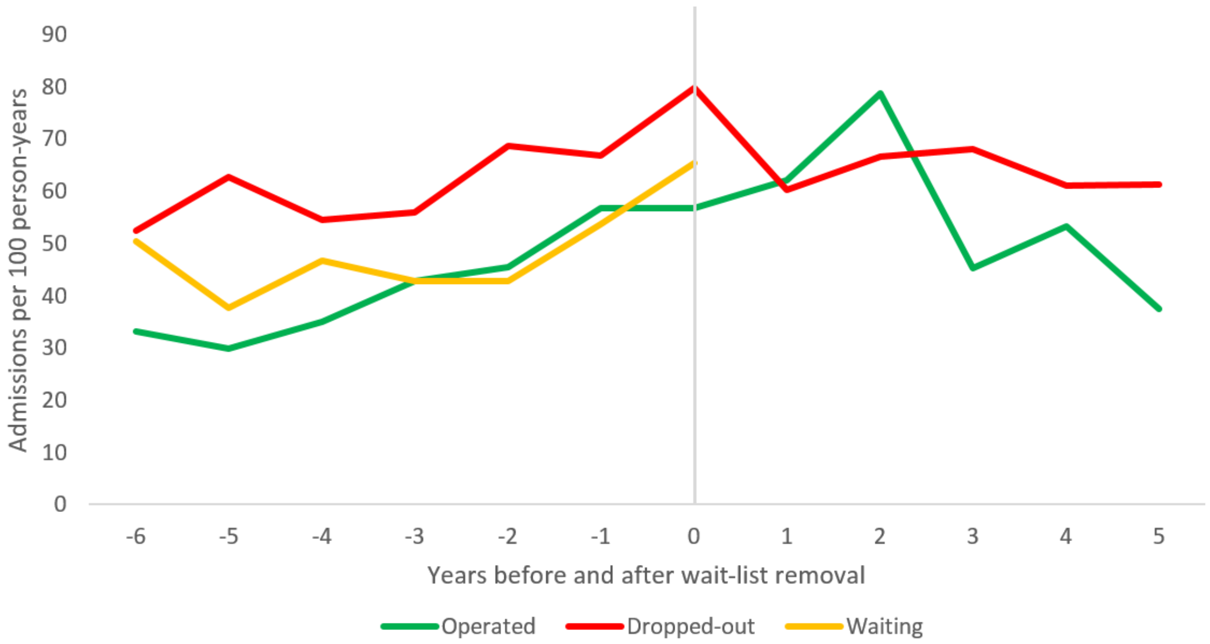

Figure 11. Trends in hospital admission rates by years from wait-list removal (represented as 0)

2.3.3 Days in hospital per year

Average rate of days in hospital per person-year was 1.1 in the operated group while on the wait-list and 2.9 in the postoperative period, while rates of days in hospital per person-year were 4.0 and 2.6 days in the dropped-out group while waiting and after wait-list removal respectively (Table 6).

The dropped-out group patients had a higher rate of days in hospital while waiting compared with the operated group (IRR 2.22, 95% CI 1.36–3.61). The number of days in hospital per year increased for the operated-on patients after LAGB (IRR 1.53, 95% CI 1.01–2.34). Detailed results are presented in Table 7.

Table 6. Days in public hospital per person-year (unadjusted)

Wait-list status	Pre wait-list	On wait-list	Post wait-list	Total
Operated	1.5	1.1	2.9	1.8
Dropped-out	2.7	4.0	2.6	3.3
Waiting/Unknown	1.5	2.4	n/a	2.1
Total	1.9	2.7	2.8	2.5

Table 7. Adjusted* public hospital length of stay incidence rate ratios (IRR) with 95% confidence intervals

Wait-list status	Period		
	Pre wait-list	On wait-list	Post wait-list
	IRR between groups		
Operated	1	1	1
Dropped-out	1.12 (0.63–1.99)	**2.22 (1.36–3.61)**	1.03 (0.63–1.70)
Waiting	0.70 (0.39–1.25)	1.43 (0.87–2.34)	n/a
	IRR between periods		
Operated	1.18 (0.73–1.90)	1	**1.53 (1.01–2.34)**
Dropped-out	**0.60 (0.40–0.88)**	1	0.71 (0.49–1.03)
Waiting	**0.58 (0.38–0.87)**	1	n/a

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold.

2.3.4 Reasons for hospital admissions

The most common reasons for most common hospital admissions were identified using major diagnostic categories (Table 8) and ICD-10 codes (Table 9).

Table 8. Admission rates (unadjusted) per 100 person-years for the most common (≥100 admissions) major diagnostic categories (MDC)

MDC	Wait-list status	Absolute numbers for the total period		Admission rates per 100 py in periods			
		Admissions	Patients	Pre wait-list	Wait-list	Post wait-list	All periods
D&D[8] of the musculoskeletal system and connective tissue	Operated	82	42	4.4	5.1	6.3	5.4
	Dropped-out	180	61	9.5	10.7	6.8	9.3
	Waiting	77	40	6.6	4.7	n/a	5.3
D&D of the circulatory system	Operated	100	41	5.6	6.7	7.0	6.5
	Dropped-out	151	62	7.5	8.1	7.7	7.8
	Waiting	51	26	2.3	4.2	n/a	3.5
D&D of the digestive system	Operated	75	41	5.6	3.8	5.7	4.9
	Dropped-out	113	63	6.1	5.2	6.8	5.9
	Waiting	83	44	5.6	5.8	n/a	5.8
D&D of the nervous system	Operated	98	29	6.8	5.7	7.0	6.4
	Dropped-out	68	38	4.3	3.5	3.0	3.5
	Waiting	40	25	3.5	2.4	n/a	2.8
D&D of the skin, subcutaneous tissue and breast	Operated	77	29	3.8	4.0	7.0	5.0
	Dropped-out	70	38	3.4	4.0	3.2	3.6
	Waiting	57	31	3.1	4.4	n/a	4.0
D&D of the respiratory system	Operated	38	23	3.0	2.4	2.3	2.5
	Dropped-out	73	42	2.9	3.3	5.5	3.8
	Waiting	84	24	7.0	5.2	n/a	5.8
Factors influencing health status and other contacts with health services	Operated	32	23	1.8	0.8	3.8	2.1
	Dropped-out	74	39	3.2	4.2	3.8	3.8
	Waiting	50	19	3.3	3.6	n/a	3.5
Mental D&D	Operated	35	9	0.3	3.0	2.7	2.3
	Dropped-out	83	14	4.8	4.1	4.3	4.3
	Waiting	20	4	1.7	1.3	n/a	1.4
D&D of the female reproductive system†	Operated	37	21	2.7	3.9	3.2	3.0
	Dropped-out	51	31	3.9	6.8	3.8	3.3
	Waiting	38	24	3.6	n/a	3.6	3.5
Injuries, poisoning and toxic effects of drugs	Operated	44	32	0.9	0.6	6.6	2.9
	Dropped-out	49	29	3.2	2.4	2.3	2.5
	Waiting	18	11	1.2	1.3	n/a	1.2
D&D of the kidney and urinary tract	Operated	25	11	0.3	1.1	3.0	1.6
	Dropped-out	60	29	3.6	2.8	3.2	3.1
	Waiting	23	11	1.2	1.8	n/a	1.6
Pregnancy, childbirth and the puerperium†	Operated	28	10	4.9	0.6	2.9	2.4
	Dropped-out	38	17	3.6	2.8	2.2	2.8
	Waiting	34	10	4.4	2.6	n/a	3.2

* D&D - diseases and disorders

†Calculated for female patient person-time only

Table 9. Admission rates per 100 person-years for the most common (≥30 patients) primary ICD-10-AM diagnoses

Primary diagnosis	Wait-list status	Absolute numbers for the total period		Period			
		Admissions	Patients	Pre-wait-list	Wait-list	Post-wait-list	All periods
Chest pain	Operated	34	25	1.5	3.0	1.8	2.2
	Dropped-out	26	19	1.8	1.2	1.3	1.3
	Waiting	18	15	1.4	1.1	n/a	1.2
Type 2 diabetes	Operated	16	12	1.8	0.8	0.9	1.0
	Dropped-out	18	23	1.6	2.6	1.1	2.0
	Waiting	12	5	0.8	0.8	n/a	0.8
Cellulitis	Operated	37	13	2.1	2.1	3.0	2.4
	Dropped-out	26	15	2.3	0.8	1.5	1.3
	Waiting	11	7	0.2	1.0	n/a	0.8
Abdominal pain	Operated	13	11	0.6	0.8	1.1	0.9
	Dropped-out	20	14	1.6	0.6	1.3	1.0
	Waiting	10	9	0.6	0.7	n/a	0.7
Cholelithiasis	Operated	15	11	1.5	0.6	1.1	1.0
	Dropped-out	18	13	0.9	0.8	1.1	0.9
	Waiting	8	8	0.8	0.4	n/a	0.6
Gonarthritis	Operated	15	11	1.5	0.5	1.3	1.0
	Dropped-out	18	15	1.4	1.0	0.4	0.9
	Waiting	8	6	0.8	0.4	n/a	0.6
Carpal tunnel syndrome	Operated	12	8	1.5	0.8	0.4	0.8
	Dropped-out	17	13	1.1	0.9	0.6	0.9
	Waiting	11	8	0.4	0.9	n/a	0.8

However, the study was underpowered to derive incidence rate ratios for groups and period comparisons using the adjusted mixed-effect model, so the data is presented for completeness and descriptive purposes. Compared with the operated-on group, the dropped-out group had higher rate of admissions for mental disorders before being placed on the wait-list (0.3 vs 4.8 admissions per 100 person-years), and for obstetrics causes and injuries, poisonings and drug intoxications while on the wait-list (0.6 vs 2.8 and 0.6 vs 2.4 admissions per 100 person-years respectively). After the surgery, there was an increase in admission rates for injuries, poisonings and intoxications (0.6 to 6.6 admissions per 100 person-years), and for pregnancy and childbirth (0.6 to 2.9 admissions per 100 person-years). Differences in other reasons for admissions between groups and periods were of less magnitude.

2.4 Discussion

Our study revealed that performing bariatric surgery as LAGB for public patients did not change the average rate of public hospital admission rates in the follow-up period of three years. This result is consistent with findings describing high rates of postoperative admission over 2 years [26] and is supported by reports of increasing postoperative admission rates for certain conditions [22, 27]. A recent Western Australian study found that overall admission rates decreased along with a significant increase in admissions for gastrointestinal causes [28]. In our study, a peak of admissions occurred during the first two years after the operation with a decreasing trend thereafter, possibly reflecting admissions for LAGB-related problems initially and suggesting that admission rates could decrease with prolonged follow-up and health status improvement due to weight loss.

LAGB was also the most commonly revised surgery in Australia during the study period [8], and conditions ultimately leading to the need of revision could also contribute to admissions in the post-operative period.

While we were not able to derive adjusted hospital admission rate ratios by MDC, and cannot state that there was a statistically significant difference in rates of admissions for different reasons, we noticed differences in admission rates for certain causes between groups and among periods. While the data do not provide sufficient evidence of higher drop-out among patients with admissions for psychiatric admissions, it is plausible that surgeons do not select these patients for surgery because a number of untreated psychiatric conditions are considered to be contraindications to bariatric surgery [29]. Higher rates of admissions for obstetric causes post-surgery could be related to improved fertility with weight loss. Also patients who got pregnant while on the wait-list could be dropped-out or postponed`, as rapid weight loss is not recommended during pregnancy [30], leaving those with lower pregnancy rates to undergo surgery. The causative link, however, should be investigated in further studies with higher number of participants.

This study is the first to report on the public hospital burden in relation to bariatric surgery measured in hospital stay days per person-year. We noticed a postoperative increase in days of hospital stay per year. This could be related to the increased complexity of patients post bariatric surgery or might reflect greater caution or additional investigations.We also discovered that patients who had bariatric surgery had lower rates of days of hospital stay in public inpatient facilities while on the wait-list than those who dropped-out.

A higher rate of days spent in hospitals per year in the dropped-out group may have reflected health conditions that were contraindications for surgery. We note that the Edmonton Obesity Score System [31] acknowledges severe obesity-related comorbidities as a possible indication for palliative measures rather than surgery, but it is unclear from the literature how often patients are diverted from bariatric surgery once placed on a wait-list. It is not clear why there was a trend towards prioritisation of younger patients.

Our literature search did not identify any similar studies comparing wait-list times in operated and dropped-out groups, although a previous study suggested an association between prolonged waiting time and attrition from bariatric surgery [15]. This finding was not supported by our study, which found no significant difference between those groups.

Among this study’s strengths, is that it included all public wait-listed patients in the state, making it free of selection bias. We established a long observation period encompassing both time prior to placement on the wait-list and while waiting for surgery, with an average of more than five years in the preoperative period and three years postoperatively. This period of observation is similar to or greater than those of other cohort studies reporting admission rates [22, 26, 27]. Patients who were wait-listed for bariatric surgery but dropped-out were used as a comparison group rather than a matched sample of general public patients, thereby decreasing the differences between the groups in terms of obesity and its comorbidities.

There are certain limitations of this study, which describes the population of a single state with a small number of surgeons performing bariatric operations, most of these being LAGB. LAGB is still the most commonly performed bariatric surgery in Tasmania, in contrast to trends elsewhere in Australia and around the world [32]. Post-operative follow-up with outpatient visits was out of the scope of this study, but variability in follow-up quality could influence hospital admission rates within the operated group. We cannot comment on hospital admission rates beyond an average of three years. We were also limited by the scope of administrative data for public patients and could not include private hospital admissions for patients who may have used both health systems. Some admissions might have been missed if patients left Tasmania or travelled interstate for healthcare. While the administrative data used to define eligible patients and their hospital admissions were adequate, the information in individual medical records was frequently incomplete, especially for patients who dropped-out from the wait-list, and hence, we could not include in our analysis variables such as weight and BMI.

While drop-out without having publicly funded bariatric surgery did not lead to an increase in rates of public hospital admissions and days in hospital per year, we caution against interpretation of the findings of increasing in-hospital stay burden for operated-on patients as negative for the public health system. When a hospital adds a surgical intervention to its scope of practice, the allocated resources must include long-term management of the condition in addition to the initial costs related to the procedure. The introduction of procedures with proven individual benefits into public hospitals is justified when the consequences of not treating a condition may be catastrophic for the individual. Moreover, the in-hospital length of stay, although a proxy for hospital costs, misses many costs that may be borne by the community, e.g., by the individual and their family, loss of productivity, or other community and health services. A treatment that saves costs for a community while transferring some costs into the hospital system may be justifiable if the community savings and well-being gain are sufficient. We think that further development of existing bariatric surgery eligibility and prioritisation guidelines will allow for better selection of patients who might benefit most from bariatric surgery and simultaneously reduce the demand on the public health system.

2.5 Conclusion

We conclude that (i) patients with a lower number of days in hospital per year, i.e., healthier patients, and younger patients were more likely to receive bariatric surgery in this high-demand setting; (ii) patients who received bariatric surgery did not have a significantly increased rate of hospital admissions during an average of three years after publicly performed LAGB compared with the wait-list period; (iii) while the rate of admissions did not change significantly after the surgery, hospital stay burden reflected as days in hospital per person-year increased after LAGB in the three year observation period; and (iv) drop-out of the wait-list for publicly funded bariatric surgery was associated with increased number of days in hospital per year, but not with an increased rate of hospital admissions while on the wait-list.

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Chapter 3: Rates and reasons for emergency department presentations of patients wait-listed for public bariatric surgery in Tasmania, Australia

Abstract

Background: Demand for bariatric surgery in the public hospital setting in Australia is high with prolonged wait-list times. Policy-makers need to consider the consequences of expanding public bariatric surgery including on emergency department (ED) presentations.

Aims: to describe and evaluate public ED presentation rates and reasons for presenting in a cohort of patients wait-listed for public surgery.

Methods: all Tasmanians placed on the public wait-list for primary bariatric surgery in 2008–2013 were identified using administrative datasets along with their ED presentations in 2000–2014. The presentations were assigned to one of three periods: before wait-list placement, whilst on the wait-list, and after wait-list removal for publicly funded surgery or drop-out. A negative binomial mixed-effects regression model was used to derive ED presentation incidence rate ratios (IRR) to compare observation periods and patient groups.

Results: 652 wait-listed patients had 5,149 public ED presentations. 178 patients had publicly funded bariatric surgery – all as laparoscopically adjustable gastric banding (LAGB). Overall, ED presentation rates did not change significantly post-surgery compared with the waiting period (IRR 1.19, 95% CI 0.90–1.56). Presentation rates significantly increased for digestive system (IRR 2.02, 95% CI 1.19–3.45) and psychiatric diseases (IRR 4.85, 95% CI 1.06–22.26) after surgery. The likelihood of being admitted from the ED significantly increased after surgery (31.7% to 38.9%, $p<0.05$).

Conclusion: ED presentations were common for patients wait-listed for public bariatric surgery and rates did not decrease over an average of three years post-LAGB. The likelihood of being admitted to the hospital from the ED increased after surgery.

3.1 Introduction

Bariatric surgery is currently the most effective treatment for resistant obesity and obesity-related diseases and is recommended for patients with severe obesity or obesity-related comorbidities and type 2 diabetes (T2DM) [1]. Its cost-effectiveness, however, remains unclear. Some studies have shown economic benefits, with reductions in healthcare costs, whereas others have demonstrated increased total costs in operated groups [2-4]. Studies have reported on patient cohorts with different health insurance status and in different healthcare systems [5], making comparisons difficult.

This uncertainty remains for not only healthcare costs but also the utilisation of healthcare facilities including through hospital admissions and emergency department (ED) presentations. Our study of hospital admissions in the Tasmanian public system demonstrated that admission rates did not decrease during three years of follow-up post-surgery and even increased in the first two years, with a decreasing trend thereafter (Chapter 2). Some studies have demonstrated that in-hospital service use decreased post-operation [6], especially for certain comorbidities [7, 8], whereas other authors have suggested that surgery increased in-hospital demands and acute presentations, especially in the first 30 days after the operation or during short-term follow-up [9].

It is unclear from the available literature whether bariatric surgery significantly influences rates and reasons for presentations to emergency departments in the long-term. During a 4-year follow-up of 174 obese patients in Brazil, emergency service use after bariatric surgery was not higher than in a non-operated obese population [10]. Nevertheless, in the majority of studies, including a longitudinal analysis of administrative data focused on short-term outcomes and re-presentations [11], postoperative emergency department presentation rates after Roux-en-Y gastric bypass (RYGB) [12] or a mix of procedures (RYGB, duodenal switch, gastric plication) [13] increased compared with the preoperative period and were more likely to be surgery-related. In a UK hospital, operated-on patients presented to emergency departments with surgery-related complications up to two years post-surgery [14].

ED presentations post-surgery do not necessarily indicate postoperative complications and are often referred to as undifferentiated abdominal pain, nausea or vomiting [15, 16] that may reflect difficulties in adjusting to lifestyle and dietary changes after surgery [17]. Such presentations, even if not leading to hospital admissions, still utilise public healthcare resources. ED presentations that lead to hospital admission increase resource use even more. The likelihood of being admitted after presentation to the ED differs greatly among studies (32–85%), depending on the type of bariatric procedure, whether the procedure was performed in the same hospital, whether the centre was compliant with optimal practice policies, and overall bariatric centre complication rates [15, 18, 19].

Insurance status also influences the risk of presentation to the ED post bariatric surgery with patients with private insurance presenting less often in a study from the United States [18]. In Australia, most bariatric procedures are performed in the private sector (88% according to the data captured by the BSR in 2017) [20], although more than 400,000 uninsured Australians may be eligible for bariatric surgery [21]. In this setting, policy-makers need to consider the range of resources required for the treatment of bariatric patients in the publicly funded health system.

When waiting for bariatric surgery for a prolonged time, patients experience worsening of their physical symptoms and increase in their weight [22, 23], that could potentially influence the ED presentation rate, however, this was not previously investigated. We hypothesised that the rates and reasons for ED presentations would increase while waiting for bariatric surgery and after receiving it. This study aimed to describe and compare the frequency, reasons and outcomes of public hospital ED presentations for all patients wait-listed for bariatric surgery in the Tasmanian public sector over a ten-year period, according to their wait-list status and outcome.

3.2 Materials and methods

This is a retrospective statewide cohort study of public ED presentations during the period 2000–2014 of all patients appearing on the public wait-list for primary bariatric surgery in the sampling period 2008–2013.

Tasmania has three main public hospitals and a number of additional small inpatient facilities. All public bariatric surgery in Tasmania is conducted in two public hospitals. All patients waiting for public bariatric surgery in Tasmania during 2008–2013 were identified using three administrative databases (multiple databases were used due to the migration of data to new systems over time and due to structural changes within the Department of Health). All databases used certain repetitive time points called "census dates", ranging from monthly to annually (depending on the database used) to represent patients' progress on the wait-list and to ensure that patients remained on the wait-list. To achieve this, patients received annual letters in response to which they had to confirm whether they still required and wished to receive surgery. Patients were placed on the wait-list after a surgical consultation following a GP referral when conservative treatment was considered ineffective. There were no mandatory requirements for patients to achieve and/or maintain certain weight loss or otherwise demonstrate compliance after being placed on the wait-list. Patients were removed from the wait-list after undergoing surgery, after submitting a response letter indicating that they did not want or did not require surgery, or after not engaging in correspondence.

We identified 776 patients appearing on wait-lists for bariatric surgery in the selected timeframe. Data on ED presentations in 2000–2014 were extracted from an administrative database. These data included ED presentation dates, ICD-10 diagnostic codes, and urgency related group major diagnostic block categories (URG MDB), and outcomes (admission or discharge).

Additional manual data extraction from digital medical records was performed for all the patients identified to ascertain hospital admissions in all inpatient facilities in 2006–2014, to obtain bariatric surgery type and whether it was primary or revisional, and to extract anthropometric data where available. After this process, 124 patients were excluded: 4 were identified as being on the wait-list for non-bariatric surgery, for 25 patients the wait-list dates were outside the study timeframe (removed before 2008 or placed after 2013), and 95 patients had had previous bariatric surgery, and therefore did not meet the inclusion criteria.

In total, 652 patients were included as wait-listed for primary bariatric surgery in Tasmania in 2008–2013 (Figure 12). Patients waiting for bariatric surgery were divided into three groups depending on the waiting outcome: 1) removed from the wait-list after undergoing a bariatric procedure (operated), 2) removed from the wait-list without a publicly funded operation (dropped-out), and 3) those who were still waiting for surgery by the end of 2014, or had disappeared from the wait-list without being actively removed for any stated reason.

All ED presentations were assigned to one of the periods in relation to wait-list placement and removal dates: 1) prior to being placed on the wait-list (pre-WL), 2) while on the wait-list (WL), 3) after removal from the wait-list for bariatric surgery or for other reasons (post-WL). Patients who disappeared from the wait-list without a record of being removed were followed up to their last census date (regular discrete time-points in the wait-list records) of being present on the wait-list. In total, 5,149 ED presentations were identified within the study period for the included patients.

ED presentation rates were calculated as presentations per 100 person-years. The reasons for presentations were determined using URG MDB (where available) in the administrative data. In calculating the ED presentation rates, we accounted for possible increased presentation rates immediately after surgery and excluded 30 patients with ED presentations within 30 days of a bariatric operation. While complications from certain bariatric procedures can persist beyond 30 days, our aim was not to exclude these delayed complications from analysis, but rather to discount generic surgical complications, that typically occur within 30 days. We also excluded eight presentations when patients were dead on arrival to the ED.

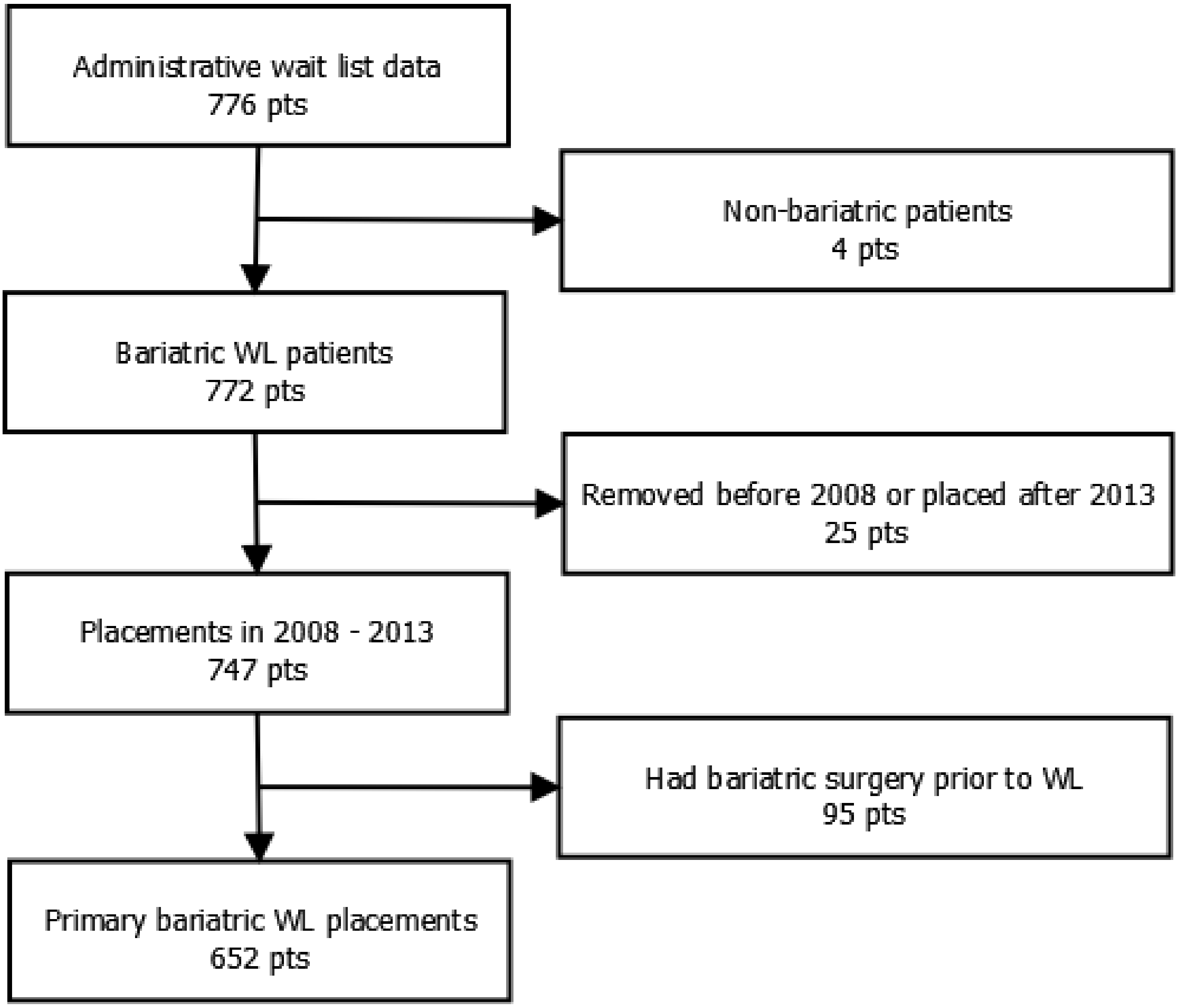

Figure 12. Patient selection flowchart

A negative binomial mixed-effects regression model of ED presentations was used to compare follow-up periods and patient groups, including an interaction term between these two variables. Mixed-effects regression with a random intercept for a participant was used because each participant had more than one (non-independent) observation period. Incidence rate ratios (IRR) were estimated by including an offset in the model – log of days at risk for each period – and the model was adjusted for sex and age at the beginning of each period. Deviance residuals were checked to ensure model fit. Adjusted incidence rate ratios were compared between periods (using the wait-list period as reference) and groups (using the operated group as reference). A similar model was used for annual incidence rate comparisons, with each year before and after removal from the wait-list being a separate period. IRRs were reported with 95% confidence intervals (CI).

Differences between patient characteristics in the operated and dropped-out groups were compared using the t-test and the χ^2 test. ED presentation outcomes as proportions admitted to hospital were compared between the operated and dropped-out groups and consecutive periods (before wait-list placement, while waiting and after surgery or drop-out) using the χ^2 test. P-values less than 0.05 were considered statistically significant. Statistical analysis was performed using Stata 14.2 software.

3.3 Results

3.3.1 Patients characteristics

Of 652 patients waiting for primary public bariatric surgery in 2008– 2013, 178 (27.3%) were operated on, 236 (36.2%) were removed from the wait-list without publicly funded bariatric surgery, and 238 (36.5%) were still waiting or disappeared from the wait-list and were followed to their last census date.

Publicly operated-on patients were, on average, younger when placed on the wait-list than those who dropped-out (42.9±11.1 vs 46.6±12.6 years, $p<0.01$). There were no significant differences in the proportions of males or Aboriginal patients between the groups. Incomplete hospital medical records prevented comparison of patients' weights and BMIs upon wait-list placement or removal. The average total observation period was 13.4±2.3 years and the average follow-up time was 2.8±1.6 years after being removed from the wait-list following public surgery or dropping-out without a publicly funded operation. The operated group had longer observation time post-WL removal than the dropped-out group, in which 21 patients were removed due to death and did not have a post-removal observation period (Table 10).

Table 10. Patient characteristics (statistically significant differences are highlighted in bold).

	Operated* (n = 178)	Dropped-out† (n = 236)	Waiting ‡ (n = 238)	Total (n=652)
Age at time of wait-list (WL) placement, years (SD)	**42.9 ± 11.1**	**46.6 ± 12.6**	43.9±12.0	44.6±12.1
Males, % (n)	24 (43/178)	31 (73/236)	26 (62/238)	27 (178/652)
Aboriginal or Torres Strait Islander origin, % (n)	6.3 (9/143)	10.6 (23/217)	6.5 (8/124)	7.4 (40/484)
Weight at time of WL placement (n), kg	125.1±29.7 (25)	122.1±19.5 (29)	137.6±36.8 (29)	128.4±30.0 (83)
BMI at time of WL placement (n)	44.0±7.6 (16)	45.3±6.8 (16)	45.6±8.8 (19)	45.0±7.7 (51)
Weight at time of WL removal (n), kg	**139.8±29.8 (89)**	**118.1±25.5 (39)**	n/a	133.2±30.2 (128)
BMI at time of WL removal (n)	**49.6±9.4 (89)**	**44.1±8.6 (22)**	n/a	48.6±9.4 (111)
Average waiting time, years	4.1±2.8	4.5±2.4	4.4±2.6	4.4±2.6
Observation time prior to WL placement, years	7.2±2.7	7.3±2.3	7.5±2.5	7.4±2.5
Observation time during WL period, years	4.1±2.8	4.5±2.4	4.4±2.6	4.4±2.6
Observation time after removal from WL, years	**3.2±1.8**	**2.5±1.4**	n/a	2.8±1.6
Total observation time, years	**14.5±0.4**	**14.1±1.3**	11.9±3.0	13.4±2.3

* Patients who had bariatric surgery.
† Patients removed from the wait-list without operation.
‡ Patients remaining on the wait-list or with unknown wait-list status at the end of the study period. Those with the unknown status accounted only for their known waiting time.

109 of 178 patients were operated in public hospitals. We were able to identify the procedure performed for all of them, which was laparoscopic adjustable gastric banding (LAGB) in all cases. For the 69 patients who were outsourced to the private hospitals using public funding, we did not have access to medical records for their surgery admission with the

procedure details. However, all outsourced publicly funded bariatric procedures were performed by a single surgeon, who confirmed that LAGB was the only type of procedure performed for these patients. This is also supported by the Medicare Benefit Schedule data for the types of procedures that were performed in the private sector in the state during the study period, with 98.9% of procedures being LAGB.

3.3.2 ED presentation rates

Among all wait-listed patients, 86.2% presented to the ED at least once, with no significant difference between operated-on and dropped-out patients. Unadjusted ED presentation rates are presented in Table 11. Over 50% of patients presented to the ED four or more times over the observation period.

Table 11. Public hospital ED presentation rates (unadjusted) per 100 person-years

Wait-list status	Pre wait-list	On wait-list	Post wait-list	Total
Operated	40.3	59.2	73.6	53.0
Dropped-out	61.5	61.2	73.3	63.3
Waiting	48.7	72.7	n/a	57.6
Total	51.1	65.0	73.6	58.4

Prior to being placed on the wait-list, patients in all groups had significantly lower ED presentation rates compared with the wait-list period (Table 12). There were no significant differences in ED presentation rates between groups in any period.

When comparing the annual ED presentation rates in the year preceding surgery (reference period) and annually postoperatively (Figure 13), we observed initially increasing rates in the first two years postoperatively with a peak in the ED presentations in the second year (IRR 1.54, 95% CI 1.01–2.36) and a subsequent decrease after that period (IRR 1.24, 95% CI 0.77–2.00).

Table 12. Adjusted* ED presentation incidence rate ratios (IRR) with 95% confidence intervals

Wait-list status	Period		
	Pre wait-list	On wait-list	Post wait-list
	IRR between groups		
Operated	1	1	1
Dropped-out	1.32 (0.96–1.81)	1.26 (0.91–1.76)	1.17 (0.83–1.67)
Waiting	1.07 (0.78–1.46)	1.23 (0.88–1.71)	n/a
	IRR between periods		
Operated	**0.69 (0.54–0.91)**	1	1.19 (0.90–1.56)
Dropped-out	**0.73 (0.59–0.91)**	1	1.10 (0.87–1.41)
Waiting	**0.61 (0.48–0.76)**	1	n/a

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold.

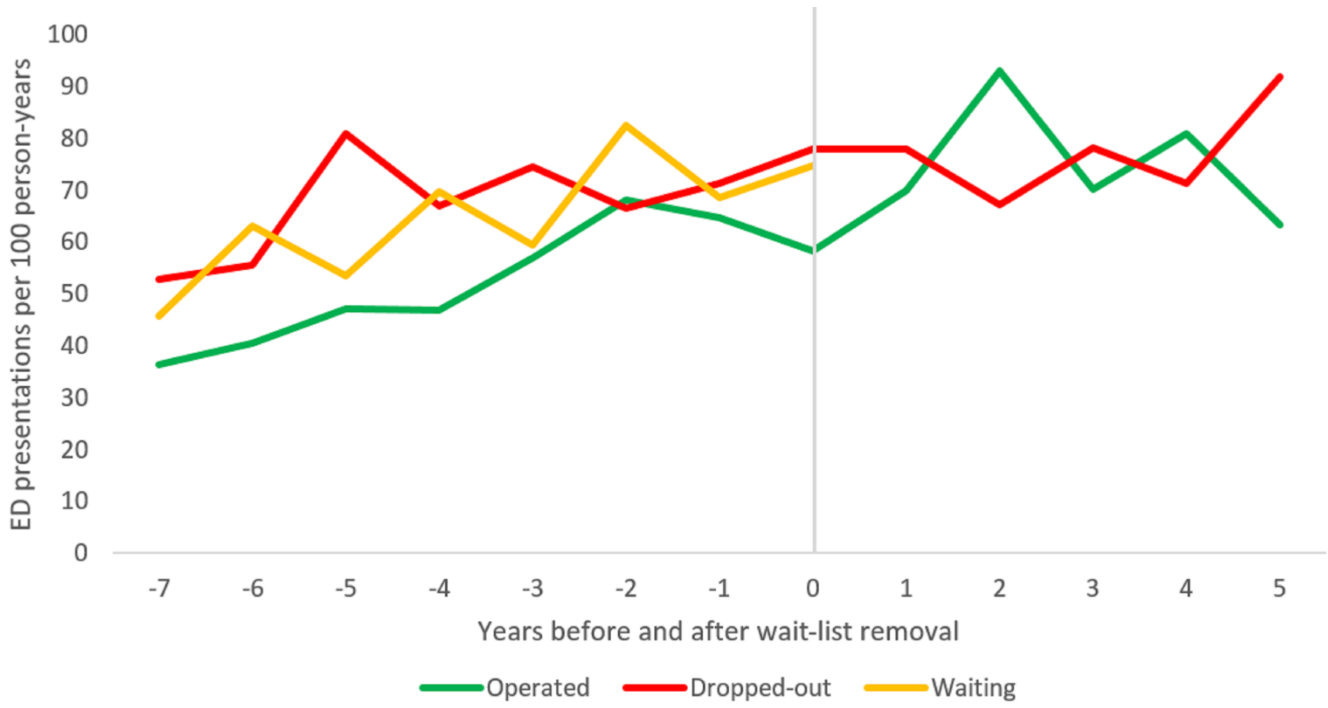

Figure 13. Trends in ED presentation rates by years relative to the time of wait-list removal (represented as 0)

3.3.3 ED episode outcomes

The proportion of patients admitted to hospital after presenting to the ED increased for all patient groups with duration of time on the wait-list over the successive periods of follow-up (pre-, during and post-wait-list) (Table 13). There was no statistically significant difference between groups in the likelihood of being admitted following presentation to the ED prior to being placed on the wait-list. During the waiting period, ED presentations in the operated group resulted in fewer admissions compared with the dropped-out patients (31.7% vs 39.4%, $p<0.05$). After the bariatric operation, however, the likelihood of being admitted following ED presentation increased significantly to 38.9%, $p<0.05$.

Table 13. Proportion of ED presentations admitted to hospital or transferred to another hospital (excluding presentations within 30 days post bariatric surgery)

	Period		
Wait-list status	Pre wait-list % (n)	On wait-list % (n)	Post wait-list % (n)
Operated	**25.5 (131)**	<u>**31.7 (140)**</u>	**38.9 (162)**
Dropped-out	**30.4 (324)**	<u>**39.4 (255)**</u>	44.3 (174)
Waiting	**20.8 (181)**	**26.3 (201)**	n/a
Total	**26.0 (636)**	**32.2 (596)**	**41.5 (336)**

* Statistically significant differences between operated and dropped-out groups are underlined, statistically significant differences between consecutive periods within groups are highlighted with bold.

3.3.4 Reasons for ED presentations

While ED presentations in the first 30 days post-surgery were not included in the rate calculation given the inevitable increase due to immediate postoperative complications, we looked at the reasons for these early ED presentations (Table 14), of which 18 (60%) could be attributed to postoperative complications.

According to the analysis by URG MDB, the most common cause for ED presentation for the overall study period was circulatory system illnesses (7.2 presentations per 100 person-years), and the presentation rate for this cause did not differ significantly between the waiting and post-waiting periods following surgery or drop-out.

Table 14. Principal diagnoses (ICD-10AM) of ED presentations (n=30) within 30 days of the primary bariatric surgery

Principal diagnosis description	Number of presentations	Percentage
Unspecified complication of the procedure	5	16.7
Wound infection following a procedure	2	6.7
Lobar pneumonia	2	6.7
Other and unspecified abdominal pain	2	6.7
Attention to surgical dressings and sutures	1	3.3
Disruption of operation wound	1	3.3
Embolism and thrombosis of unspecified vein	1	3.3
Postprocedural disorder of digestive system, unspecified	1	3.3
Surgical follow-up care, unspecified	1	3.3
Hypoglycaemia	1	3.3
Acute stress reaction	1	3.3
Bronchitis not specified	1	3.3
Cervicalgia	1	3.3
Follow-up examination after unspecified treatment	1	3.3
Hordeolum	1	3.3
Open wound to finger(s)	1	3.3
Other specified abnormal uterine or vaginal bleeding	1	3.3
Other specified disorder of teeth and support structures	1	3.3
Other inflammatory disorders of penis	1	3.3
Procedure not done, patient declined	1	3.3
Superficial injury of forearm	1	3.3
Syncope and collapse	1	3.3
No ICD-10 code	1	3.3

When the presentation rates during the wait-list time were compared with those during the postoperative period for the operated group, there was a significant increase in rates of presentations for digestive system illnesses (IRR 2.02, 95% CI 1.19–3.45). Moreover, compared with the dropped-out group, operated-on patients were significantly more likely to present to the ED with digestive system illnesses in the post-wait-list period (11.01 vs 5.41 per 100 person-years, $p<0.01$).

In the operated group there was a significant increase in the postoperative period in presentations for urological system illness (1.27 to 5.68 per 100 person-years), mainly due to urinary tract infections in the remote period, that could not be attributed to the immediate postoperative catheter-related infections, or to dehydration acute kidney injury.

The dropped-out patients tended to have a higher rate of psychiatric presentations than the operated group initially (pre-wait-list IRR 4.17, 95% CI 0.97–17.91) and while on the wait-list (IRR 4.03, 95% CI 0.82–19.70). When comparing periods, for the operated-on patients ED presentation rates for psychiatric illnesses increased significantly after the surgery (IRR 4.85, 95% CI 1.06–22.26).

Details of the presentation rates by the most common URG MDB are summarised in Table 15.

3.4 Discussion

We found that rates of ED presentations increased after the wait-list placement (as expected for patients referred for surgical treatment of obesity compared with the earlier period when they did not require it), and that ED presentation rates did not decrease after publicly funded bariatric surgery performed as LAGB even after excluding presentations within 30 days of surgery. Studies comparing postoperative resource utilisation for up to four years after various bariatric procedures, such as LAGB, RYGB and sleeve gastrectomy, also found no decrease in ED visits [6, 10].

While there was a peak of presentations within 2 years after the surgery and an increase in presentations for certain conditions after the surgery, overall postoperative ED presentation rates were not higher compared with the dropped-out group.

Table 15. Adjusted* ED presentation incidence rate ratios (IRR) with 95% confidence intervals for the most common (≥100 presentations) urgency related group major diagnostic blocks (URG MDB) excluding presentations within 30 days post bariatric surgery

URG MDB	Wait-list status	Absolute numbers for the total period		Periods		
		Presentations	Patients	Pre wait-list	On wait-list	Post wait-list
Circulatory system illness	Operated	172	53	**0.37 (0.21–0.64)**	1	0.80 (0.47–1.37)
	Dropped-out	273	104	**0.56 (0.37–0.86)**	1	0.98 (0.62–1.55)
	Waiting	162	75	**0.43 (0.27–0.68)**	1	n/a
Injuries	Operated	159	65	**0.33 (0.20–0.57)**	1	1.00 (0.59–1.70)
	Dropped-out	208	80	**0.48 (0.32–0.73)**	1	0.95 (0.59–1.53)
	Waiting	184	81	**0.47 (0.31–0.71)**	1	n/a
Other presentation (not specified)	Operated	131	67	**0.30 (0.16–0.55)**	1	1.33 (0.77–2.31)
	Dropped-out	174	69	0.78 (0.47–1.32)	1	1.61 (0.92–2.82)
	Waiting	164	58	**0.42 (0.25–0.70)**	1	n/a
Digestive system illness	Operated	138	63	**0.39 (0.22–0.71)**	1	**2.02 (1.19–3.45)**
	Dropped-out	168	85	**0.57 (0.36–0.90)**	1	1.03 (0.60–1.75)
	Waiting	116	61	**0.25 (0.15–0.42)**	1	n/a
Neurological system illness	Operated	114	51	**0.33 (0.18–0.64)**	1	0.62 (0.32–1.19)
	Dropped-out	167	62	0.63 (0.37–1.08)	1	1.31 (0.73–2.37)
	Waiting	103	55	**0.32 (0.18–0.55)**	1	n/a
Respiratory system illness	Operated	52	28	**0.34 (0.14–0.83)**	1	1.00 (0.43–2.32)
	Dropped-out	129	54	0.73 (0.40–1.32)	1	1.53 (0.79–2.97)
	Waiting	154	54	**0.37 (0.22–0.65)**	1	n/a
System infection	Operated	81	29	**0.40 (0.16–0.99)**	1	1.13 (0.47–2.71)
	Dropped-out	146	59	0.53 (0.28–1.01)	1	1.28 (0.63–2.59)
	Waiting	79	45	**0.30 (0.15–0.61)**	1	n/a
Psychiatric illness	Operated	31	16	0.68 (0.13–3.64)	1	**4.85 (1.06–22.26)**
	Dropped-out	97	27	0.70 (0.26–1.93)	1	0.84 (0.27–2.59)
	Waiting	42	16	1.19 (0.33–4.33)	1	n/a
Urological system illness	Operated	45	18	0.33 (0.08–1.27)	1	1.56 (0.49–4.92)
	Dropped-out	50	28	**0.36 (0.14–0.93)**	1	0.89 (0.33–2.37)
	Waiting	39	26	0.65 (0.27–1.55)	1	n/a
Hepatobiliary system illness	Operated	37	21	1.09 (0.33–3.56)	1	1.05 (0.25–4.24)
	Dropped-out	35	15	0.84 (0.25–2.84)	1	1.16 (0.27–4.92)
	Waiting	36	14	0.41 (0.13–1.34)	1	n/a
Musculoskeletal/ connective tissue system illness	Operated	19	14	0.54 (0.16–1.84)	1	0.91 (0.25–3.31)
	Dropped-out	48	33	1.26 (0.53–2.94)	1	1.50 (0.57–3.95)
	Waiting	37	24	**0.25 (0.11–0.60)**	1	n/a

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold

Two studies with three months follow-up of all ED presentations post-RYGB or various procedures reported an increased number of conditions related to the surgery itself, e.g. postoperative complications [15, 17]. Supporting this notion, an increase in gastrointestinal presentations was also found in some other studies as a post-procedure complication, with abdominal pain being one of the most common reasons for ED presentation in the short-term

[12, 24]. Our study also revealed a significant increase in presentations for gastrointestinal illnesses within several years after bariatric surgery.

Some studies have reported that patients present with mental health disorders more often after bariatric surgery than before [25, 26], and, in our study, a significant increase in presentations for psychiatric illnesses occurred in the publicly-operated group after the surgery. However, the absolute presentation rates were low, 1.3 per 100 person-years while waiting for surgery and 2.7 per 100 person-years post-operatively. Compared with the operated group, the dropped-out group tended to have higher presentation rates for psychiatric conditions both before and while waiting.

Patients who had bariatric surgery were more likely to be admitted from the ED after surgery than before surgery. Their postoperative admission rate of 38.9% is similar to the admission rate of 34.9% in the study by Telem, although the latter study examined short-term presentations only after different types of bariatric procedures (LAGB, RYGB, sleeve gastrectomy) [18]. No studies known to us have compared the pre- and postoperative likelihood of admission. It is not clear whether the prevalence of conditions requiring admission during ED visits increased, whether medical practitioners were more inclined to admit postoperative patients, or whether this increase simply reflects an overall trend of greater severity of health conditions over time.

Some economic evaluations show that costs eventually decrease a few years after surgery [2], although not immediately in the first years [5]. Further analysis is required to determine the economic effects for public hospitals. Our findings of non-decreasing rates of ED presentations and an increased likelihood of admission from the ED after bariatric surgery suggest that the policy of performing publicly funded bariatric surgery as LAGB did not reduce the burden on the public hospital system in Tasmania. However, further analysis is required to determine the economic impact for public hospitals as this study was looking at service use rather than overall costs. Costs of ED presentations comprise only a fraction of total costs for the public system which include hospital admissions, inpatient time, outpatient costs and, particularly relevant to bariatric surgery, costs of revisional procedures [27, 28].

This study should not be interpreted as a comparison of operated-on patients with non-operated-on patients, but rather as a comparison of patients who had publicly funded surgery with those who dropped-out from the public wait-list, even if they went on to have privately-funded surgery, either self-funded or through private insurance. The study aimed to inform public payers of wait-list patient pathways and their impacts on hospital services use.

Given that some reasons for hospital admissions and ED presentations changed significantly after bariatric surgery, costs are also expected to change and require evaluation. Moreover, there could be cost drift from individuals to public healthcare. It has been argued that increased hospital resource use and even increased costs should not limit access to public bariatric surgery due to the expected health benefits and mortality reductions [29].

This study included all patients wait-listed for primary public bariatric surgery in Tasmania and provided a long observation period of 13 years on average, which is greater than the observation periods reported in other studies of ED presentations. The postoperative observation period of three years is similar or greater than those in other studies [12, 15, 17, 18]. Outcomes for the operated group were compared with those of a similar population of patients who were eligible for surgery in the public hospital system (as defined by placement on the wait-list). Few studies of healthcare resource utilisation have had comparison groups closely resembling the treatment group, if they have been available at all [10].

Our study did not provide comparisons between bariatric surgery types because all the procedures were LAGB. In a study of 36,673 patients that compared ED presentation rates not resulting in admissions within 90 days post-surgery, and that included different types of bariatric procedures, LAGB was associated with lower ED presentation rates than sleeve gastrectomy or RYGB [15]. Similar results were shown in a study of ED presentations resulting in readmissions within 30 days for 130,007 patients [30]. In studies comparing sleeve gastrectomy and RYGB only, RYGB was associated with higher rates of ED presentations within one year in a study of 5,701 patients [31] and in a Saudi study of 301 patients operated within a five-year period without details of average follow-up time [32]. However, most of these studies were comparing short-term follow-up data only, representing immediate post-surgical complications (and excluded for that reason from our study), and no conclusions on long-term emergency department presentations rates for different procedures could be drawn.

This study has certain important limitations. It encompasses the population of only a single state, with a small number of bariatric surgeons operating publicly and laparoscopic adjustable gastric banding as the most commonly performed procedure (in contrast to current national and world trends [33]). While multidisciplinary management and long-term follow-up are associated with better LAGB results [34-36], and long-term complication rates are typically higher for patients lost for follow-up [37], our study was not able to account for patients' adherence to postoperative follow-up.

We also had to assume the type of publicly funded procedures outsourced to private hospitals, basing on routine surgeons' practice. We relied on Tasmanian administrative databases, and thus, patients who left Tasmania or had emergency presentations while in other areas were not captured. Presentations to private hospital emergency departments could also not be tracked. Due to the inferior quality of the hospital medical records, we were not able to examine the relationships of ED presentations with weight and BMI; however, it is usual for administrative databases not to have anthropometric data, and for studies based on administrative data not to report on such associations [9, 18].

This study does not provide information on the impact of waiting time on public ED presentation rates. Future studies with a matched sample of individuals who are not wait-listed for surgery would help to differentiate between aging and waiting time contributions to ED presentation rates.

3.5 Conclusion

We conclude that (i) the overall ED presentation rate did not decrease after publicly funded laparoscopic adjustable gastric banding; (ii) overall ED presentation rates were similar following publicly funded operations and drop-out from the wait-list; (iii) there were increases in specific ED presentation reasons after LAGB particularly for digestive system problems and psychiatric illnesses, with rates increasing for psychiatric illnesses after being placed on the wait-list; the absolute risk, however, remained low. and (iv) the likelihood of being admitted during an ED presentation increased after LAGB surgery.

The results of the study suggest that publicly funded bariatric surgery performed as laparoscopic adjustable gastric banding does not reduce the burden on the public healthcare system in terms of emergency department service use over an average of three years. Further economic analysis is required to quantify the cost implications.

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Chapter 4: Reoperations after secondary bariatric surgery: a systematic review

Abstract

This chapter reviews reoperation rates for short-and long-term complications following secondary bariatric procedures and need for further bariatric surgery. The search revealed 28 papers (1317 secondary cases) following at least 75 % of patients for 12 months or more. For adjustable gastric banding (AGB), rebanding had higher re-revisional rates than conversions into other procedures. Conversion of AGB to Roux-en-Y gastric bypass had the highest number of short- (10.7%) and long-term (22.0%) complications. We estimated 194 additional reoperations per 1000 patients having a secondary procedure, 8.8 % needing tertiary surgery.

Despite being poorly reported, risks of reoperations for long-term complications and tertiary bariatric surgery are higher than usually reported risks of short-term complications and should be taken into account when choosing a secondary bariatric procedure and for economic evaluations.

4.1 Introduction

Morbid obesity is a chronic condition with a significant burden on public healthcare. Bariatric surgery is currently the most effective way of treating morbid obesity and related diseases, particularly type 2 diabetes mellitus (T2DM) [1, 2]. As with any surgery, it does not have a 100% success rate, and complications, insufficient weight loss or poor comorbidity control may indicate the need for further bariatric operations. The reported incidence of bariatric surgery revisions has been as high as 50% in some series [3-5]. National registry data from Sweden, the UK and Russia indicate 3–8% of procedures are secondary bariatric operations, and as many as 17–20% in reports of other nations (United Arab Emirates, Netherlands) [6].

In the past decade, there have been many publications on bariatric revisions, and revisional workshops and discussions attract considerable attention at bariatric conferences [7]. Surgeons have realised that the initial operation might be only the first step in the management of bariatric patients, but a Cochrane Collaboration review on bariatric surgery in adults revealed adverse event rates and reoperation rates are poorly reported [8].

The true economic costs of bariatric surgery are therefore likely to be higher than have so far been reported, as most analyses to date have failed to account for the need for subsequent surgery, with a few exceptions [9, 10]. The only economic evaluation that does address this issue assigned the same probability for reoperation after all procedures [11].

While technical details of reoperations are described well and knowledge of the short-term complications of revisional procedures is evolving rapidly, there is little information on what happens after revisional operations, what are the rates of long-term complications, and what is the rate of subsequent revisional bariatric surgery (re-revisions). Our systematic review aimed to describe patient pathways and the need for further surgery following a secondary bariatric procedure.

4.2 Materials and methods

In order to make results generally applicable, we looked only at conventional primary and secondary procedures such as adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG), biliopancreatic diversion (BPD) and BPD with duodenal switch (BPD-DS). Vertical banded gastroplasty (VBG) was also included because although it is almost abandoned, secondary operations are still performed in such patients.

Terms for reoperative surgery are defined in Table 16. Our protocol to search PubMed and Cochrane databases used combinations of the terms “secondary”, “readmission” and “reoperation” combined with “bariatric”, “gastric banding”, “gastric bypass”, “sleeve gastrectomy”, “duodenal switch”, “biliopancreatic diversion” and “banded gastroplasty”, including their derivatives, in titles, abstracts, citations and terms. All identified review articles were also screened for references. The search was limited to ten years (2004–2014) to reflect changes in techniques and the widespread use of sleeve gastrectomy. Languages chosen for inclusion were English, Spanish, German, Russian, Ukrainian (papers in all those languages were used to identify pathways; however, only papers in English were finally included in the quantitative analysis). Only original studies of any design containing ten or more cases of revisions, reversals or conversions were eligible for inclusion. In order to make results of the review more generalisable, we excluded uncommon operative methods, with yet unestablished similarity of outcomes to conventional revisional, such as robotic surgery, single incision laparoscopic surgery, natural orifice transluminal endoscopic surgery and all endoscopic revisions. The range of primary procedures was limited to the conventional operations used as search terms. Based on the protocol definition of revisional, conversional and reversal procedures, we excluded operations that were performed after primary bariatric procedures for specific or non-specific complications and that did not change the anatomy created by the original procedure, i.e., hernia repairs, operations for internal hernias, surgical drains, and body contouring procedures. Patient pathways were identified during the full-text analysis; we constructed flow-charts of the sequence of procedures that patients underwent and excluded studies if a definite sequence of procedures could not be identified for each patient.

Table 16. Terms for reoperative bariatric surgery used in the review.

Term	Definition	Examples
Revision	Operation that corrects or modifies anatomy of a bariatric procedure to improve the outcome in cases if this anatomy differs from originally intended or if it had not led to the planned outcome. This includes also device-related manipulations that do not lead to conversion or reversal as defined below.	Resection of a dilated gastric pouch Re-sleeve gastrectomy Changing of limb length in Roux-en-Y gastric bypass for insufficient weight loss Gastric band replacement for band slippage
Conversion	Changing anatomy of a bariatric procedure into anatomy of another distinct recognised bariatric procedure	Roux-en-Y gastric bypass after LAGB Duodenal switch after sleeve gastrectomy
Reversal	Operation that restores original anatomy of GI tract	Gastric band removal* Restoration of anatomy after RYGB
Secondary bariatric procedure	Revision, conversion or reversal of a primary bariatric operation	
Tertiary bariatric procedure	Revision, conversion or reversal of a secondary bariatric procedure	
Band repositioning	Revision of gastric banding with correction of band position using the previously placed band	
Band replacement	Revision of gastric banding using a new adjustable gastric band	
Rebanding	Any of two previously mentioned revisional procedures involving replacement or repositioning of an adjustable gastric band	

*Staged procedures with reversal as the first step and intentions at that moment to perform the second step were considered as a single conversion procedure (e.g., planned two-stage conversion of adjustable gastric banding to sleeve gastrectomy).

After identification of all possible pathways, papers were assessed to extract data on primary and secondary outcomes. The primary outcomes for this review were the rates of tertiary and subsequent bariatric procedures. Secondary outcomes were rates of complications, reoperations for reasons other than correction of a secondary bariatric procedure, and mortality. Complications were divided into short-term complications that occurred in the first 30 days after surgery and long-term complications occurring after more than 30 days.

Two reviewers assessed the quality of papers independently; papers that did not comply with the following criteria were excluded:

1. Reporting all primary and secondary outcomes.
2. Reporting both follow-up duration and proportion of followed patients after the secondary procedure.
3. Average follow-up duration after the secondary procedure of at least 12 months.
4. Follow-up reported for 75% or more of patients.
5. Both primary and secondary outcomes had to be attributable to a clearly specified sequence of primary and secondary procedures.

Patients were grouped according to the types of primary operations they had received, and subgroups were formed according to the secondary bariatric procedure. Relative risks (RR) were calculated for the pooled data, reported with 95% confidence intervals, χ^2 tests and Fisher's exact tests were used to measure and compare differences between subgroups; p-values less than 0.05 were considered statistically significant. Statistical analysis was performed using Stata 12.1 software.

4.3 Results

After the initial search and removal of publications that duplicated study results, we identified 1591 papers, of which 106 contained traceable pathways for secondary bariatric procedures in 4734 patients.

Of the identified papers, 28 had sufficient follow-up duration and proportions for 1317 patients to be included in the quantitative analysis. The process of paper selection is depicted in Figure 14.

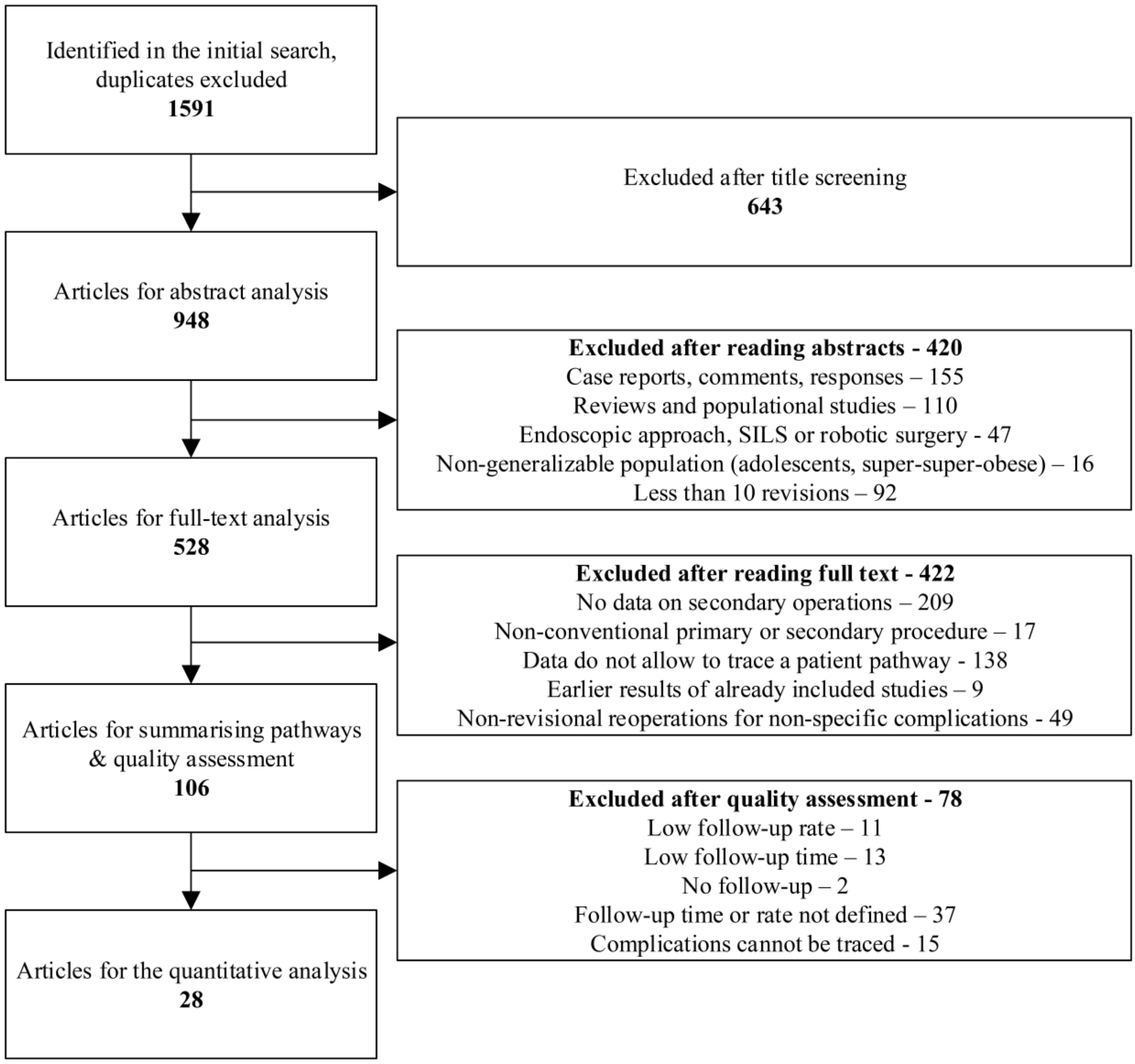


Figure 14. Schematic diagram of the selection process for the studies included in the review.

Detailed patient pathways based on the studies with sufficient follow-up are shown in Figure 15 (a–e by type of initial surgical procedure). Primary and secondary outcomes are summarised in Table 18. Table 19 reveals additional information on the reoperations for long-term complications of secondary bariatric surgery.

Reoperations after secondary bariatric surgery were common, with 194 re-reoperations for different causes per 1000 secondary procedures (regardless of the number of stages); with 8.8% of patients receiving a tertiary bariatric procedure and 9.6% patients being reoperated for long-term complications of secondary bariatric procedures (these figures partially overlap).

This does not take into account body contouring operations that were not reported in any of the studies.

Table 17. Studies selected for the quantitative analysis.

#	Study	Year	Years of primary and/or secondary operations	Patients (n)	Primary procedure	Secondary procedure	Average follow-up duration (months)	Follow-up proportion (%)
1	Aarts [12]	2013	2000–2010	38	LAGB	Band removal	36	100
2	Bueter [13]	2009	-	41	LAGB	Band replacement 18, Band repositioning 7, Band removal 12, SG 2, RYGB 2	56	93
3	Cordera [14]	2004	1986–2003	54	VBG	RYGB	73	94
4	Cusati [15]	2011	1990–2009	24	RYGB	RYGB revision	14	100
5	Dapri-1 [16]	2009	2002–2007	27	LAGB	SG	18.6	85
6	Dapri-2 [17]	2011	-	26	SG	Re-SG 7, DS 19	24.4	92
7	Dargent [18]	2009	1995–2008	98	VBG	AGB	69	78
8	Ee [19]	2013	1998–2009	163	LAGB	Band replacement	36	75
9	Foletto [20]	2008	2000–2007	29	LAGB	Band replacement	26.9	100
10	Gagne [21]	2011	1999–2010	105	VBG	RYGB	26	100
11	Gautier [22]	2013	2005–2010	18	SG	RYGB	15.5	100
12	Himpens [23]	2010	2002–2010	40	AGB	SG	32.6	90
13	Iannelli [24]	2013	2009–2011	20	RYGB	RYGB revision	20	100
14	Khan [25]	2013	-	20	LAGB	SG	26	100
15	Niville [26]	2005	1999–2001	10	LAGB	Removal	48	100
16	Perathoner [27]	2013	2002–2012	108	AGB	RYGB	41	89
17	Poyck [28]	2012	2003–2008	35	AGB	DS	36	83
18	Rawlins [29]	2011	2002–2009	29	RYGB	Distal RYGB	27	100
19	Rebibo [30]	2012	2007–2011	15	SG	Re-SG	12	100
20	Schouten [31]	2006	1997–2005	29	AGB	Band replacement 5, Band repositioning 19, BPD 3, RYGB 2	34	100
21	Schouten [32]	2007	-	101	VBG	RYGB	38	100
22	Silecchia [33]	2013	2008–2011	76	AGB	SG	24	100
23	te Riele [34]	2008	2002–2006	55	AGB	RYGB	12.8 (median)	100
24	Thill [35]	2009	2001–2008	40	VBG	AGB	18	98
25	Thoreson [36]	2008	1993–2008	27	VBG	Reversal	32	96
26	Uglioni [37]	2009	2004–2007	29	AGB	SG	24	95
27	van Wageningen [38]	2006	1999–2004	47	AGB	RYGB	12	87
28	Wenger [39]	2005	-	13	VBG	AGB	52	100

LAGB – laparoscopic adjustable gastric banding, BPD – biliopancreatic diversion, RYGB – Roux-en-Y gastric bypass, SG – sleeve gastrectomy, VBG – vertical banded gastroplasty

Table 18. Outcomes of secondary bariatric surgery.

Primary procedure	Secondary procedure	Patients, n	Studies[a], n	Short-term complications, n (%)	Long-term complications, n (%)	Complications requiring reoperation[b], n (%)	Tertiary operations, n (%)	Reoperations for insufficient weight loss[c], n (%)	Mortality, n (%)	Bariatric procedures after primary per person	Average number of operations per person[d]
AGB	Total	747	15	52 (7.0)	93 (12.4)	89 (11.9)	86 (11.5)	51 (6.8)	0	1.13	1.32
	Rebanding	241	4	2 (0.8)	34 (14.1)	34 (14.1)	49 (20.3)	15 (6.2)	0	1.24	1.25
	Replacement	215	4	0	29 (13.5)	29 (13.5)	44 (20.5)	15 (6.2)	0	1.25	1.26
	Repositioning	26	2	1 (3.8)	5 (19.2)	5 (19.2)	5 (19.2)	0	0	1.19	1.19
	SG	194	6	16 (8.2)	5 (2.6)	7 (3.6)	9 (4.6)	9 (4.6)	0	1.05	1.49
	RYGB	214	5	23 (10.7)	47 (22.0)	43 (20.1)	1 (0.5)	0	0	1.00	1.62
	BPD/BPD-DS	38	2	8 (21.1)	7 (18.4)	5 (13.2)	0	0	0	1.00	1.16
	Reversal	60	3	2 (3.3)	0	0	27 (45.0)	27 (45.0)	0	1.47	1.48
VBG	Total	438	7	68 (15.5)	91 (20.8)	74 (16.9)	28 (6.4)	12 (2.7)	2 (0.5)	1.06	1.20
	AGB	151	3	8 (5.3)	13 (8.6)	16 (10.6)	16 (10.6)	7 (4.6)	0	1.11	1.15
	RYGB	260	3	57 (21.9)	78 (30.0)	58 (22.3)	12 (4.6)	5 (1.9)	2 (0.8)	1.05	1.25
	Reversal	27	1	3 (11.1)	0	0	0	0	0	1.0	1.0
SG	Total	59	3	8 (13.6)	3 (5.1)	9 (15.3)	0	0	1 (1.7)	1.0	1.15
	Re-SG	22	2	4 (18.2)	0	3 (13.6)	0	0	1 (4.5)	1.0	1.14
	RYGB	18	1	1 (5.6)	0	1 (5.6)	0	0	0	1.0	1.06
	BPD-DS	19	1	3 (15.8)	3 (15.8)	5 (26.3)	0	0	0	1.0	1.26
RYGB	Total	73	3	24 (32.9)	17 (23.3)	8 (11.0)	1 (1.4)	0	0	1.01	1.11
	Distal RYGB[e]	29	1	14 (48.3)	16 (55.2)	7 (24.1)	1 (3.4)	0	0	1.03	1.24
	Pouch or anastomosis revision	44	2	10 (22.7)	1 (2.3)	1 (2.3)	0	0	0	1.0	1.02
Total		1317	28	152 (11.5)	204 (15.5%)	180 (13.7)	116 (8.8)	64 (4.9)	3 (0.2)	1.10	1.26

LAGB – laparoscopic adjustable gastric banding, BPD – biliopancreatic diversion, DS – duodenal switch, RYGB – Roux-en-Y gastric bypass, SG – sleeve gastrectomy, VBG – vertical banded gastroplasty

a – Some studies included several revision types, so total may not be equal to the sum of the column.

b - Including tertiary bariatric operations for complications.

c - Or weight regain leading to tertiary procedure.

d - Two-stage procedures counted as two operations; reoperations for complications of tertiary and following procedures are included; primary bariatric procedure is not included.

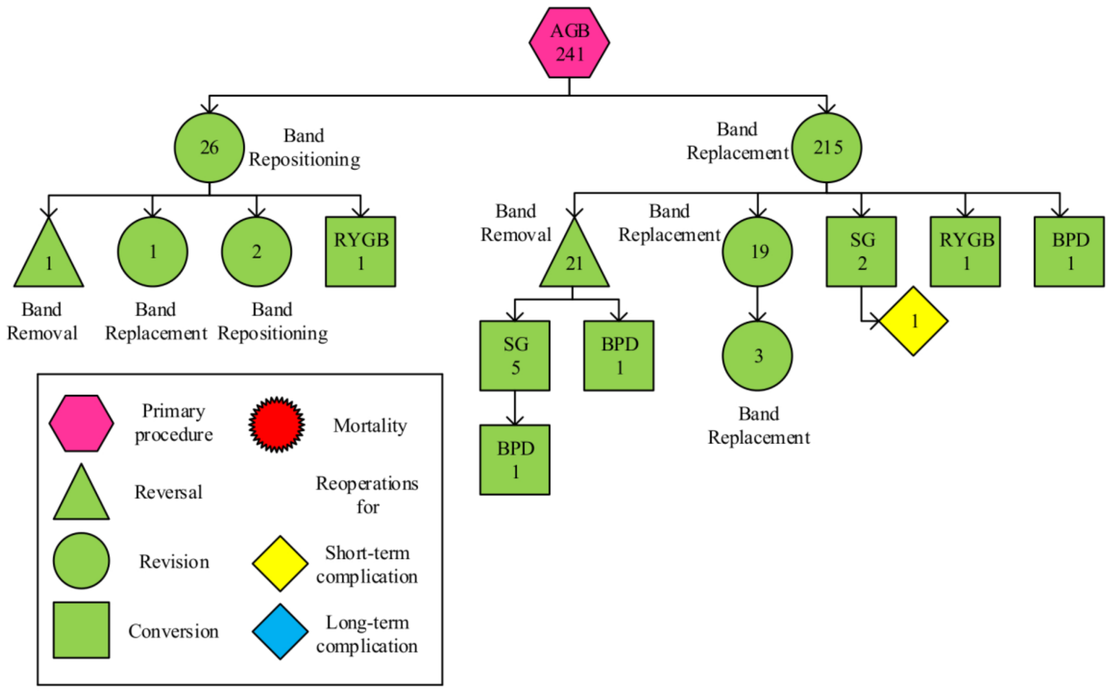
e – Distal RYGB with long biliopancreatic limb

Table 19. Summary of long-term complications of secondary bariatric surgery requiring reoperation.

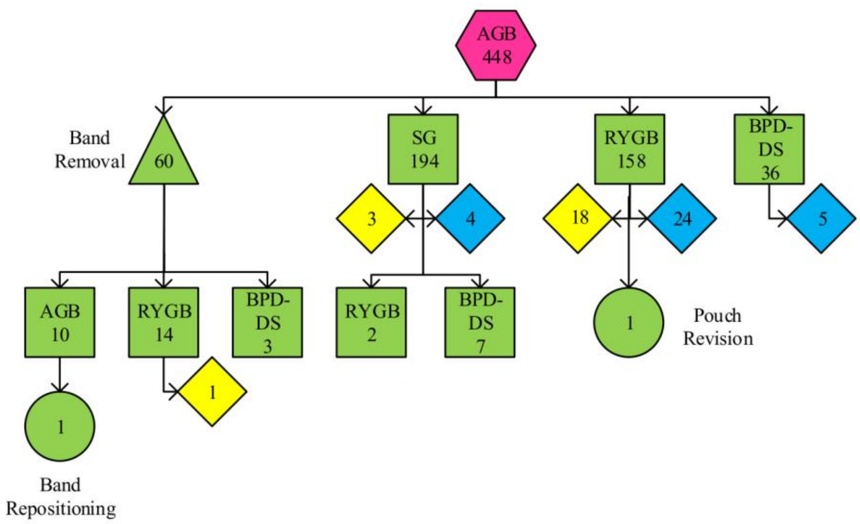
Primary procedure	Secondary procedure	Patients, n (studies, n)	Incisional / trocar hernia, n (%)	Small bowel obstruction, n (%)	Stricture or stenosis, n (%)	Surgical site infection, n (%)	Alimentary, n (%)	Leak or fistula, n (%)	Internal hernia, n (%)	Other[a], n(%)	Band related[b], n (%)	Total
AGB	Total	747 (15)	24 (3.2)	5 (0.7)	0	3 (0.4)	0	2 (0.3)	0	3 (0.4)	31 (12.8)	68 (9.1)
	Rebanding	241 (4)	0	0	0	3 (1.2)	0	0	0	0	31 (12.8)	34 (14.1)
	Replacement	215 (4)	0	0	0	2 (0.9)	0	0	0	0	27 (12.6)	29 (13.5)
	Repositioning	26 (2)	0	0	0	1 (3.8)	0	0	0	0	4 (15.4)	5 (19.2)
	SG	194 (6)	2 (1.0)	0	0	0	0	1 (0.5)	0	1 (0.5)	n/a	4 (2.1)
	RYGB	214 (5)	17 (7.9)	5 (2.3)	0	0	0	1 (0.5)	0	2 (0.9)	n/a	25 (11.7)
	BPD/BPD-DS	38 (2)	5 (13.2)	0	0	0	0	0	0	0	n/a	5 (13.2)
	Reversal	60 (3)	0	0	0	0	0	0	0	0	n/a	0
VBG	Total	438 (7)	22 (5.0)	1 (0.2)	3 (0.7)	0	0	3 (0.7)	3 (0.7)	7 (1.6)	9 (6.0)	48 (11.0)
	AGB	151 (3)	1 (0.7)	0	0	0	0	0	0	0	9 (6.0)	10 (6.6)
	RYGB	260 (3)	21 (8.0)	1 (0.4)	3 (1.2)	0	0	3 (1.2)	3 (1.2)	7 (2.7)	n/a	38 (14.6)
	Reversal	27 (1)	0	0	0	0	0	0	0	0	n/a	0
SG	Total	59 (3)	1 (1.7)	0	0	0	2 (3.4)	0	0	0	n/a	3 (5.1)
	Re-SG	22 (2)	0	0	0	0	0	0	0	0	n/a	0
	RYGB	18 (1)	0	0	0	0	0	0	0	0	n/a	0
	BPD-DS	19 (1)	1 (5.3)	0	0	0	2 (10.5)	0	0	0	n/a	3 (15.8)
RYGB	Total	73 (3)	6 (8.2)	0	0	0	1 (1.4)	0	0	0	n/a	7 (9.6)
	Distal RYGB[c]	29 (1)	6 (20.7)	0	0	0	1 (3.4)	0	0	0	n/a	7 (24.1)
	Pouch or anastomosis revision	44 (2)	0	0	0	0	0	0	0		n/a	0
Total		1317 (28)	53 (4.0)	6 (0.5)	3 (0.2)	3 (0.2)	3 (0.2)	5 (0.4)	3 (0.2)	10 (0.8)	40 (10.2)	126 (9.6)

LAGB – laparoscopic adjustable gastric banding, BPD – biliopancreatic diversion, DS – duodenal switch, RYGB – Roux-en-Y gastric bypass, SG – sleeve gastrectomy, VBG – vertical banded gastroplasty, SSI – surgical site infection.
Subgroup differences with $p < 0.05$ are highlighted in bold.
a – biliary colic / cholelithiasis, hiatal hernia, 'candy cane' Roux limb.
b – proportions for band-involving operations only presented.
c – distal RYGB with long biliopancreatic limb.

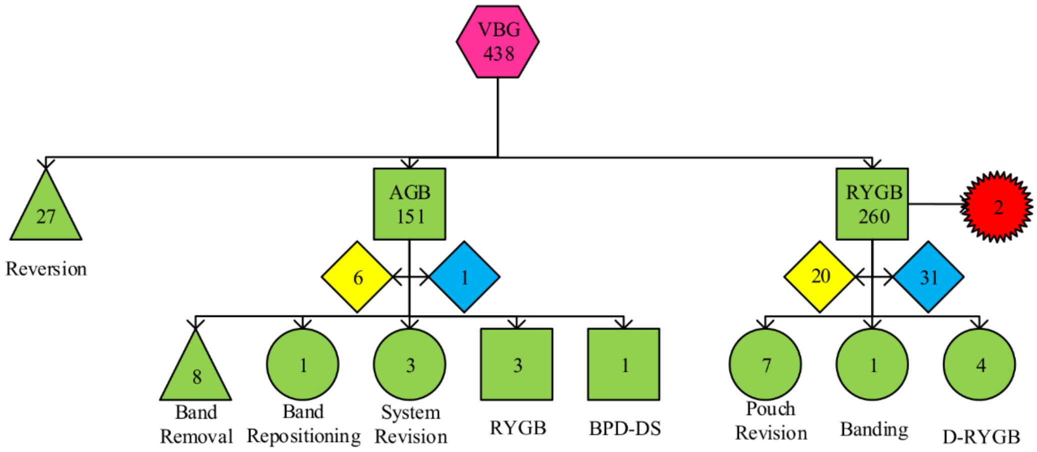
Figure 15. Details of bariatric reoperations in studies following patients for one year or more (AGB – adjustable gastric banding, BPD – biliopancreatic diversion, DS – duodenal switch, D-RYGB – distal Roux-en-Y gastric bypass, SG – sleeve gastrectomy, RYGB – Roux-en-Y gastric bypass, VBG – vertical banded gastroplasty):



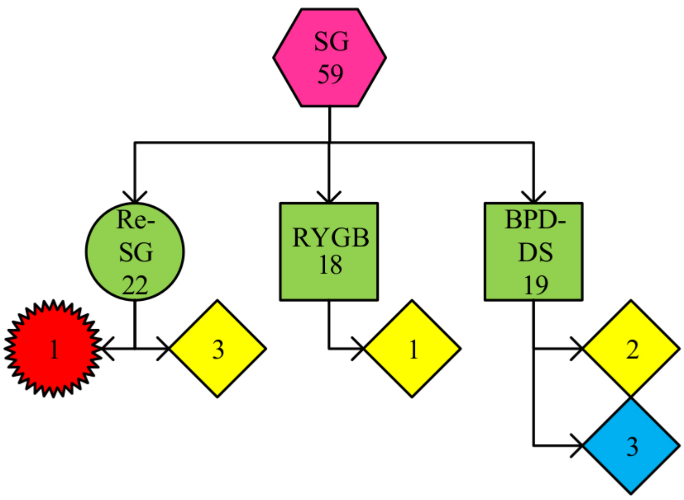
a) Adjustable gastric banding revisions



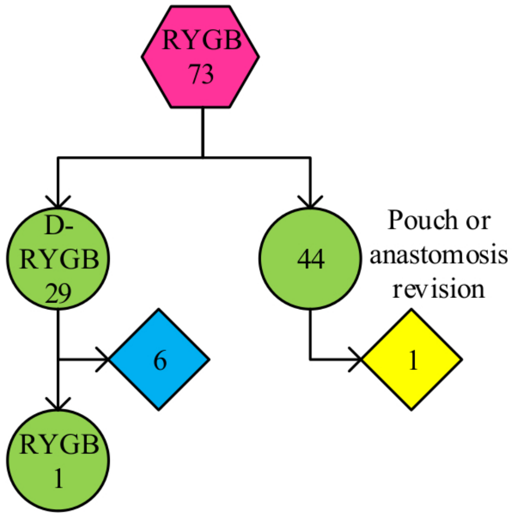
b) Adjustable gastric banding reversals and conversions



c) Reoperations for vertical banded gastroplasty



d) Reoperations for sleeve gastrectomy



e) Reoperations for Roux-en-Y gastric bypass

Initially, the relative risk calculation was planned using a model weighting outcomes according to follow-up proportions and durations. However, on applying the model, it appeared that studies with lower follow-up proportions captured more events of interest, and assigning lower weights to those studies would result in a significant decrease in event proportions that would likely not truly reflect the underlying outcome rates. Therefore, unadjusted relative risks are presented.

4.3.1 Bariatric reoperations after AGB

Conversion of AGB into RYGB, as compared to other revision operations, had the highest complication rates (Table 18), both in the long and short term ($p<0.001$), with 10.7% short-term and 22.0% long-term complications. RYGB, when compared to rebanding, also had a trend towards a slightly higher long-term complication rate as a secondary procedure (RR 1.4, 95% CI 0.9–2.1, $p=0.09$). It is possible that the difference in this outcome was influenced by different reasons for the type of revision, however we could not establish a definite pattern for the revision choice in the studies included in the analysis. In the studies where LAGB was converted to different procedures the reasons for RYGB choice were opposite: insufficient weight loss [13] and initially good weight loss with gastric band intolerance [31], and other studies were addressing only a single type of revision for different reasons. The rate of complications requiring reoperations did not differ significantly between sub-groups of RYGB and rebanding ($p=0.27$). Sleeve gastrectomy after AGB had the lowest reported long-term complication rates (2.6%) and required the least number of reoperations for complications (RR 0.2, 95% CI 0.1–0.4, $p<0.001$) compared to other types of secondary procedures, with only 2.1% of reoperations for long-term complications.

Performing any type of gastric banding as a revisional operation resulted in higher re-revisional rates for any reason (complication or weight loss failure) than conversions into other procedures (RR 2.7, 95% CI 2.3–3.2, $p < 0.0001$), mostly due to reoperations for band-related complications (12.8%).

Rates of tertiary reoperations for insufficient weight loss or weight regain were similar in patients who had band repositioning or replacement and those with sleeve gastrectomy after gastric banding (RR 1.1, 95% CI 0.8–1.6, $p=0.53$) and were performed in less than 7% of patients of those subgroups. In contrast, no tertiary operations were due to insufficient weight loss in patients converted from AGB to RYGB or BPD, which is statistically significant when compared to rebandings or conversions to SG ($p=0.001$).

The total reoperation rate did not differ significantly between rebandings and conversions to RYGB after AGB, but the most common reason for operations for long-term complications after conversion to RYGB was incisional hernia repair (17 out of 25, or 68% of all reoperations performed for RYGB complications after 30 days). The only reported revision of RYGB after AGB was due to gastro-gastric fistula.

4.3.2 Bariatric reoperations after vertical banded gastroplasty

Results of VBG conversion to AGB or RYGB were different; although the rate of tertiary operations was higher after AGB, with 10.6% of conversions to AGB being revised vs 4.6% of conversions to RYGB (RR 1.6, 95% CI 1.1–2.3, p=0.03), the rate of complications requiring reoperations was significantly lower, with 10.6% conversions to AGB being reoperated for complications compared to 22.3% conversions to RYGB (RR 0.5, 95% CI 0.3–0.8, p<0.01). This resulted in a higher average number of operations per person when VBG was converted to RYGB rather than to AGB (p=0.03).

4.3.3 Bariatric reoperations after sleeve gastrectomy

Re-SG and conversions to RYGB or BPD-DS were included in this group. However, the number of patients with long-term follow-up after reoperations for sleeve gastrectomy was small, and there were no differences in complication (p=0.12) and reoperation (p=0.21) rates between subgroups. However, all (15.8%) long-term reoperations were in the BPD-DS subgroup.

4.3.4 Bariatric reoperations after Roux-en-Y gastric bypass

No reversals or conversions of RYGB were included in the analysis, although there were reports in the excluded studies. Revisions of RYGB were divided into two subgroups depending on the area and type of revision. Results of pouch reduction or gastrojejunoanastomosis revision were compared with lengthening of biliopancreatic limb. Despite no difference in the rate of tertiary operations (p=0.4), distal RYGB resulted in higher complication rates and more reoperations for complications (RR 2.6, 95% CI 1.7–4.0, p<0.01). In total, lengthening of the biliopancreatic limb resulted in short-term complications in 48% of patients (surgical site infections and deep vein thrombosis), and 55% experienced long-term complications (abdominal wall hernias, malnutrition, small bowel obstruction). However, the comparison included only a single cohort in each subgroup.

4.4 Discussion

There is a big gap in the literature on medium- to long-term outcomes of revisional bariatric surgery. This review is the first summary of patient surgical pathways after secondary bariatric surgery with the aim of improving our understanding of the reoperations and complications rates after secondary bariatric surgery. It was challenging to address this in a systematic way for a number of reasons. While the current literature contains information on patient pathways following secondary bariatric surgery, papers do not typically report reoperations and long-term complications in a structured way, so sequences of complications and reoperations could be reconstructed only after a thorough full-text analysis. Moreover, difficulties in tracking reoperations arise because of a lack of centralised databases for bariatric surgery outcomes that would allow follow-up of patients who migrate between bariatric centres. Some of the studies, especially in large centres, reported performing secondary or even tertiary operations for patients coming from other clinics. Overall, the actual numbers of published cases of tertiary and subsequent operations remain very low compared to the amount of publications on short-term outcomes of revisional bariatric surgery, possibly due to publication bias.

Surprisingly, the number of published studies looking at the long-term results of sleeve gastrectomy revisions is very low, despite enormous numbers of the procedure performed. Those studies with longer follow-up duration did not follow-up sufficient proportions of patients, nor did they report outcomes in a structured way to allow non-ambiguous data extraction, resulting in only 59 patients being included in this review. The same was true for mini-gastric bypass, with only one study meeting our criteria identified, and this failed to differentiate reoperations after conversions to RYGB and SG.

Despite these challenges, the findings suggest that reoperations after secondary bariatric surgery are common, but their rates and, more often, reasons vary by type of primary and secondary procedure. Particular issues arise with AGB; high re-revision and weight loss failure rates after gastric rebanding suggest that retaining the gastric band at the time of a secondary procedure may not be the optimal choice. For example, a prospective study of secondary AGB and RYGB by Muller found 45% of failures after rebanding compared to 20% after conversion to RYGB [40]. Another interpretation of inferior rebanding results is that the reason for failure of the primary AGB may well be inadequate follow-up [41]. If a rebanding is followed by further poor follow-up, repeated poor results would not be surprising. Eating training and band follow-up with experienced adjusting have been shown to be important for optimal results from AGB. Management with AGB should be envisioned as the AGB surgery plus ongoing experienced support.

Conversions of all types of primary procedures (except SG) into RYGB or BPD-DS appear to carry an increased risk of incisional hernia, likely due to an increased number of laparotomies or conversion to laparotomies, but those rates could not be ascertained from most of the studies. Another common complication was malnutrition after conversion to BPD-DS or distal-RYGB, although it was usually managed without further reoperations.

In contrast, in reoperations for VBG, AGB may be a better option than RYGB because despite significant increases in the need for tertiary operations after band placement, the clinical significance of more complications and reoperations for complications after conversion to RYGB may prevail. However, there are no studies comparing long-term outcomes of different secondary strategies to provide more conclusive recommendations.

Another notable finding of this review is the high rate of bariatric procedures after bariatric reversals (up to 45% after AGB removal) [12, 42, 43]. Very few studies have looked at what happened to patients after their procedure was reversed, so the actual number of patients who return to bariatric surgeons after re-evaluating their decision might be even higher. Overall, the long-term outcomes of band removals are uncertain because patients are often lost to follow-up and tend to re-appear in reports only after they decide to have another bariatric procedure. In addition, reversals of other (non-AGB) operations can result in further bariatric procedures [44]. Therefore, as stated by Buchwald, a reversal of a bariatric operation should not mean the end of the professional obligation for ongoing care [7], as future operations may still be required.

Quantitative weight loss outcomes after reoperations were not evaluated in this review due to the heterogeneity of the studies included but this is still an important question and should be investigated in a more specific study. Quality of life after revisional bariatric surgery is also an under-investigated topic. Patient stories cannot be fully represented in statistics of failures and reoperations, and sequential procedures are burdensome for patients. Wenger tells of a patient who developed band intolerance after VBG followed by AGB but declined further operations and lived on liquids only [39]. This implies that long-term studies of sufficient length are required to investigate the impact of subsequent surgery on health-related quality of life.

Additional costs associated with long-term complications, reoperation probabilities and weight loss failure after secondary bariatric operations should also be addressed in economic models evaluating bariatric surgery, which generally fail to account for them.

Long-term nationwide follow-up of all bariatric patients, regardless of their current procedure status, is needed to fully assess the outcomes of bariatric surgery. There are methods to achieve this in large population groups, including through bariatric registries in the UK, Sweden and Russia [6] that distinguish between primary and secondary operations and follow their outcomes. Existing bariatric registries could provide a snapshot of trends and long-term outcomes of secondary bariatric procedures on a countrywide scale, though published reports have not specifically described this subgroup of procedures. There is no summary of outcomes in low- and high-volume centres and whether results of centres specialising in secondary treatments are different from standard high-volume centres.

There are several limitations of this review. The main limitation comes from the scope of the included studies, which were mostly case series of a single revision type without a comparison group and with insufficient follow-up to establish long-term outcomes of different secondary procedures. In addition, our focus was not on the primary outcomes of the reviewed studies (excessive weight loss mainly) but rather on the extracted co-reported data, which could be incomplete. The analysis of case-series rather than comparative studies made it impossible to evaluate publication bias using standard methods.

In summary, this review has revealed the gaps in the literature that limit our understanding of patient outcomes after secondary bariatric operations and the medical attention this population needs. In fact, the whole discussion section may seem to be focused on limitations of implications of the results of the study; however, this is the main finding, that current literature does not properly address this large and complex group of patients.

Overall, based on the findings of this review, we recommend the following: (i) more thorough data capture of bariatric reoperations and their outcomes, including in bariatric registries; (ii) continued evaluation of outcomes for patients after bariatric reversals; (iii) well-designed comparative studies to determine optimal secondary procedures after specific primary operations; (iv) accounting for the need for additional operations after secondary bariatric surgery in economic evaluations; and (v) studies of quality of life after secondary bariatric surgery using validated generic and disease-specific instruments.

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Chapter 5: Public hospital waiting-time and service use for primary vs revisional bariatric surgery recipients in Tasmania, Australia: a statewide cohort study

Abstract

Background: Most bariatric surgery procedures in Australia are performed in the private sector but many eligible patients are uninsured. This creates significant pressure on the public system. Australia-wide, public hospitals perform a higher proportion of revisional procedures than private hospitals (36% vs 25%), possibly limiting access to primary procedures. This study investigated proportions of publicly funded bariatric surgery that were primary and revisional and explored waiting times and public hospital service use by patients wait-listed for revisional surgery compared with those who only had primary bariatric surgery in Tasmania, Australia.

Methods: Data on all patients wait-listed for public bariatric surgery in 2008–2013 and their public hospital admissions and ED presentations during 2006–2014 were extracted from administrative databases and digital medical records. Hospital admission and emergency department (ED) presentation rates and days in hospital per year were compared between those who received primary bariatric surgery only and patients ever wait-listed for revisional surgery using incidence rate ratios of these variables between primary-only and revisional surgery recipients and between periods on the wait-list and after surgery. IRRs were derived using a negative binomial regression mixed-effects model adjusting for age, sex and non-independent observation periods.

Results: In total, 273 patients had publicly funded surgery with laparoscopically adjustable gastric bands (LAGB) or were wait-listed for LAGB revisions. 178 (27.3%) of 652 patients wait-listed for primary bariatric surgery and 90 (94.7%) of 95 patients wait-listed for LAGB revisions had their operations as planned. Out of a total of 320 bariatric surgery

procedures, 142 (44.8%) were performed for revisional surgery including unplanned and second or subsequent revisions. The mean wait-list time for primary surgery was significantly longer than for any subsequent revisional surgery: 4.1±2.8 vs 0.8±1.0 years. Compared with primary-only surgery recipients, revisional surgery recipients had higher public hospital admission rates (IRR 2.60, 95% CI 1.63–4.13 while on wait-list and IRR 1.98, 95% CI 1.31–2.98 post-surgery); more days in hospital per year (IRR 2.68, 95% CI 1.44–4.99 while on wait-list and IRR 2.10, 95% CI 1.18–3.76 post-surgery); and higher ED presentation rates after the surgery (IRR 1.76, 95% CI 1.15–2.70).

Conclusion: Revisions constituted a substantial proportion of publicly funded bariatric surgery in Tasmania. Patients requiring revisional surgery used more hospital services than primary surgery recipients before and after their respective surgery. Bariatric surgery planning in the public sector should make adequate provision for revisional surgery patients to account for their more frequent and prolonged hospital in-patient stays and increased rates of ED presentations.

5.1 Introduction

Bariatric surgery is currently the most effective treatment for morbid obesity and related comorbidities [1] and is recommended in guidelines for publicly funded practice in some countries [2-4]. According to the International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) Global Registry, 52.1% of operations were funded by public health services with wide variation (0–100%) among countries [5, 6]. The demand for bariatric surgery is substantial, and in publicly funded systems such as in the UK or Canada, only a small minority of patients eligible for bariatric surgery receive it [7, 8]. The majority of bariatric procedures (88%) in Australia are performed in the private sector [9], but many patients eligible for surgery experience socioeconomic disadvantage or have no private insurance (46%), which creates increasing pressure on the public system [10]. The need to prioritise patients who will benefit the most and calls for the expansion of public service provision have emerged. Nevertheless, a recent review suggests that in many countries, the only criterion for prioritising bariatric surgery patients in the publicly funded health system is waiting time [11], whereas from some patients' and clinicians' perspectives, other prioritisation criteria based on the clinical staging of obesity are considered more appropriate [12].

Reoperations after bariatric surgery are common. Commonly named revisional bariatric surgery or revisions, these operations include correction or modification of bariatric procedures, conversions into a different type of procedure or restoration of the original anatomy (reversal) [13]. National registries and individual country reports demonstrate rates of revisional surgery of 3–8 % in the UK, Sweden, Russia and France [5, 14], with certain countries such as Belgium, France, the Netherlands performing even more revisional surgeries [15]. According to the Australian Institute of Health and Welfare (AIHW) data for 2014–2015, 37% of bariatric procedures performed in Australian public hospitals were revisional. However, the AIHW does not provide data on the proportions of surgery that are revisional in

Tasmania, Northern Territory and Australian Capital Territory [16]. The BSR report, while not capturing all Australian data, showed that in 2016–2017 in the participating private hospitals, 25% of bariatric procedures were revisional, whereas 36% of procedures were revisional in the public system [9]. As more primary surgeries are performed, the demand for revisional bariatric surgery is also expected to increase, as evidenced in the Australian public system, where in 2005 only 20% of procedures were revisional [16]. However, existing guidelines and recommendations have not considered revisional surgery as a separate entity when determining indications for surgery and patient prioritisation [4].

Revisional bariatric surgery, in comparison with primary surgery, is also associated with significantly higher complication and adverse event rates [17], as shown in an Australian report in which 7.3% of revisional procedures had a complication (unplanned return to theatre, admission to intensive care unit or re-admission to hospital) compared with 2.4% of primary procedures [9]. Therefore, the increasing numbers of revisional procedures are likely to create an additional burden on the public health system in the postoperative period that should be taken into account by service planners.

We have previously shown long waiting times for patients wait-listed for primary public bariatric surgery in Tasmania (Chapter 2). We hypothesised that patients placed on the wait-list for revisional bariatric surgery would have shorter wait-list times and higher public hospital service use than primary bariatric surgery recipients. This retrospective statewide cohort study aimed to assess the demand for revisional bariatric surgery in the public sector, and to evaluate the accessibility of publicly funded bariatric surgery and the use of public hospital services by patients wait-listed for revisional compared with primary bariatric surgery.

5.2 Materials and methods

This retrospective statewide cohort study included all public hospital admissions and emergency department presentations in 2006–2014 for patients who had primary or revisional surgery following placement on the wait-list for public bariatric surgery in Tasmania in 2008–2013. There are three main public hospitals in Tasmania and several small inpatient facilities. Bariatric surgery in Tasmania is performed in the public and private systems: public surgery is performed in two public hospitals, with some procedures outsourced to private hospitals but funded publicly.

All patients placed on the wait-list for public bariatric surgery in Tasmania in 2008–2013 were identified using three administrative databases (multiple databases contain this information due to system migration over time and structural changes in the state Department of Health). The wait-list data contained dates of wait-list placements and removals as well as removal reasons (e.g., procedure completed, patient lost to follow-up or procedure not required).

Additional extraction of data from hospital medical records was performed to identify placements for revisional bariatric surgery (if they had notes for previous bariatric surgery or procedure details suggesting a revision of a previous bariatric procedure). Detailed recording of anthropometric data was poor for most patients in the hospital records and therefore did not allow us to perform an analysis of patients' weights and BMIs.

All public hospital admissions in all public inpatient facilities and all emergency department presentations to all three public hospitals in the period 2006–2014 were extracted from the administrative databases. Data on admissions and emergency presentations included dates and reasons for service utilisation (ICD-10 codes, diagnosis-related groups and urgency-related groups).

To compare primary bariatric surgery recipients who did not require further revision with those who required revisional surgery, patients were divided into two groups: 1) patients who received primary bariatric surgery only and were never considered for revisional bariatric surgery in the sampling period of 2008–2013, or to the end of follow-up after surgery to the end of 2014; and 2) those who were ever wait-listed for revisional bariatric surgery during the 2008–2013 sampling period. Patients who were wait-listed for primary bariatric surgery and were still on the wait-list (n=238) or were removed from the wait-list without receiving primary bariatric surgery (n=236) were excluded from the analysis.

We examined the waiting times for primary and revisional surgery, the proportion of bariatric surgery procedures in the public system that were revisional, and the proportion of patients undergoing revisional surgery in the public system whose primary bariatric surgery was not included in public system records after 2006 – these patients were assumed to have undergone their primary bariatric surgery privately, though this could not be ascertained. All public hospital admissions and emergency department presentations were assigned to a period in relation to the wait-list time. For the recipients of only primary bariatric surgery, these periods were (a) while waiting and (b) after the primary procedure. For the patients ever wait-listed for revisional surgery, the periods were (a) while waiting for revisional surgery and (b) after removal from the wait-list, whether for revisional surgery or drop-out. If a patient had more than one revisional surgery wait-list placement, then only the first placement was used to define these periods. Additionally, to ensure the validity of the observation periods, patients were linked to the Tasmanian death registry and the observation periods were adjusted to the dates of death for patients who died before the end of 2014.

Admission records with interfacility transfer were treated as single admission. When calculating admission rates and days of hospital stay per year, admissions for planned wait-listed bariatric procedures were excluded, as well as admissions for bariatric procedures that were subsequently cancelled or postponed. ED presentation rates were calculated excluding ED presentations within 30 days post-surgery (as an increase in presentations was expected in this period). Total admission and emergency department presentation rates included person-time for people without any admissions or ED presentations during the study period. Person-time for admissions was reduced by the length of hospital stay in each period because patients were not at risk for another admission while admitted. They were still at risk for ED presentations though, such as during interfacility transfer.

A negative binomial mixed-effects regression model was used to derive incidence rate ratios (IRR) with 95% confidence intervals (CI) for hospital admissions, days in hospital per year and ED presentation rates between observation periods and groups, including interaction between these two variables. Mixed-effects regression with a random intercept for participant was used due to non-independent observation periods for individual participants. IRRs were estimated for time at risk in each period, and the model was adjusted for sex and age at the start of each period.

Differences between patients' characteristics were compared using χ^{2-} and t-tests, and p-values less than 0.05 were considered significant. Statistical analysis was performed using Stata 14.2 software.

5.3 Results

5.3.1 Bariatric surgery pathways and outcomes

We identified 652 patients who were wait-listed for primary bariatric surgery, of whom 178 (27.3%) had a primary procedure in the study period. Of the 178 patients, 109 had primary bariatric surgery (laparoscopic adjustable gastric banding – LAGB) in public hospitals. The remaining 69 patients had publicly funded bariatric surgery outsourced to private hospitals and no additional records on procedure details were available. However, it was ascertained by the only surgeon performing outsourced publicly funded bariatric operations, that all the procedures were LAGB. Of the 178 patients who received primary bariatric surgery after being on the wait-list in the sampling period, 9 (5.1%) were later wait-listed for a secondary bariatric procedure and were included in the revisional group for the hospital service use analysis. Additionally, through hospital admission details, we identified 4 more patients who had non-wait-listed revisional surgery. A further 95 patients were identified who were wait-listed in the same period initially for revisional bariatric surgery. A total of 64 (67.4%) had no previous records of bariatric surgery in the public system and were assumed to have had primary surgery in the public system prior to the study period or to have been transferred from the private system.

Of the 95 patients initially wait-listed for revisional surgery, 90 (94.7%) received the surgery for which they were listed, compared with 178 (27.3%) out of 652 patients wait-listed for primary surgery in the same period. Only four (4.2%) patients awaiting a revision dropped-out from the wait-list, though two of these patients later had a non-planned revisional surgery. Patients' pathways following wait-list placements and surgical procedures are depicted in Figure 16 and Figure 17.

In total, there were 138 wait-list placements for revisional surgery (including second and subsequent revisions), of which 130 (94.2%) placements resulted in revisional surgery. The average waiting time for the primary procedure was 4.1±2.8 years, with a maximum waiting time of 11.3 years, whereas the average waiting time was 0.8±0.9 years, with a maximum waiting time of 6.7 years, for the first revisional procedure ($p < 0.0001$) and 0.8±1.0 years across all revisional procedures including subsequent revisions.

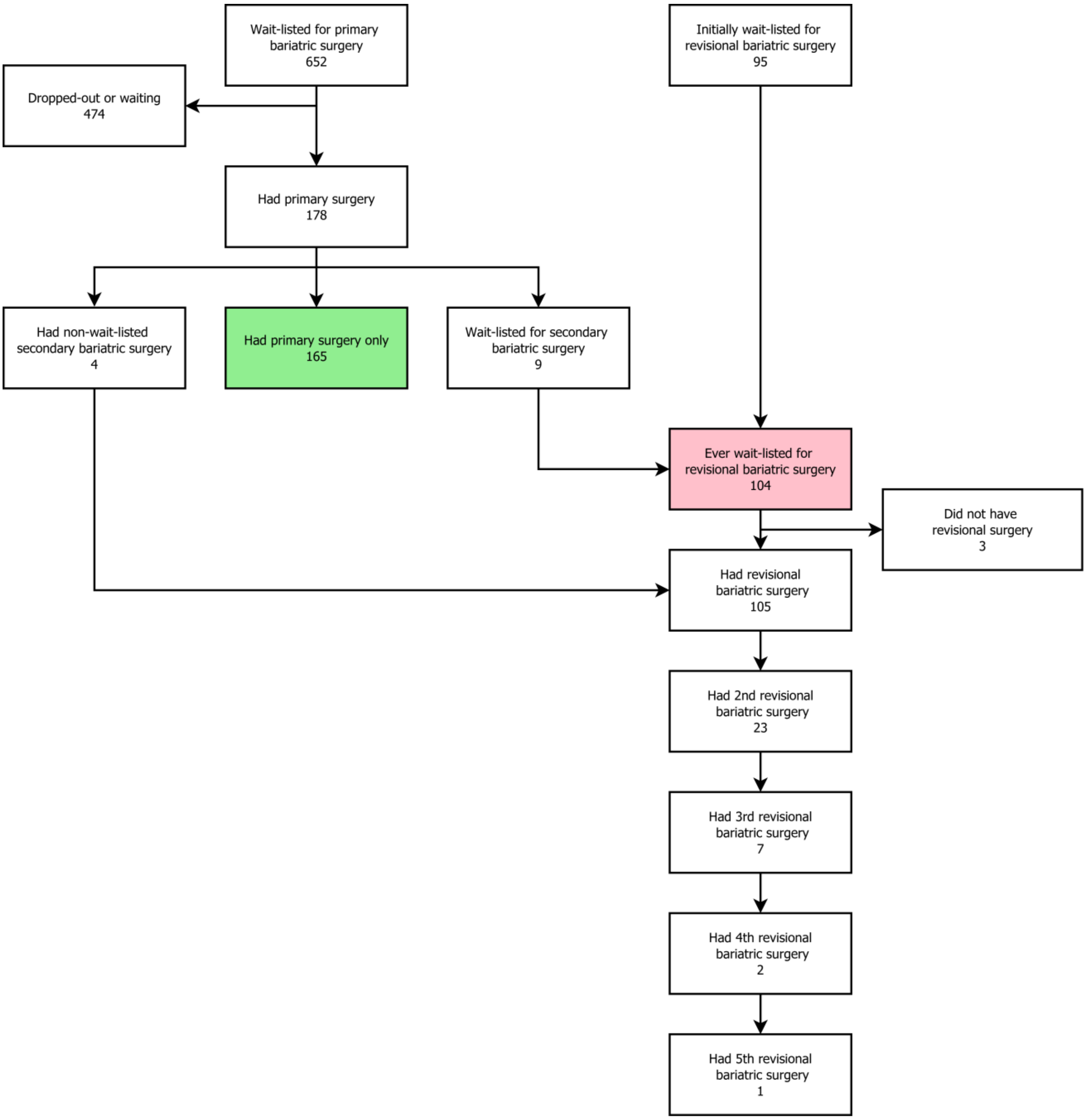

Figure 16. Flowchart summarising patient pathways (compared groups highlighted: primary surgery only – green, wait-listed for revisional surgery – red)

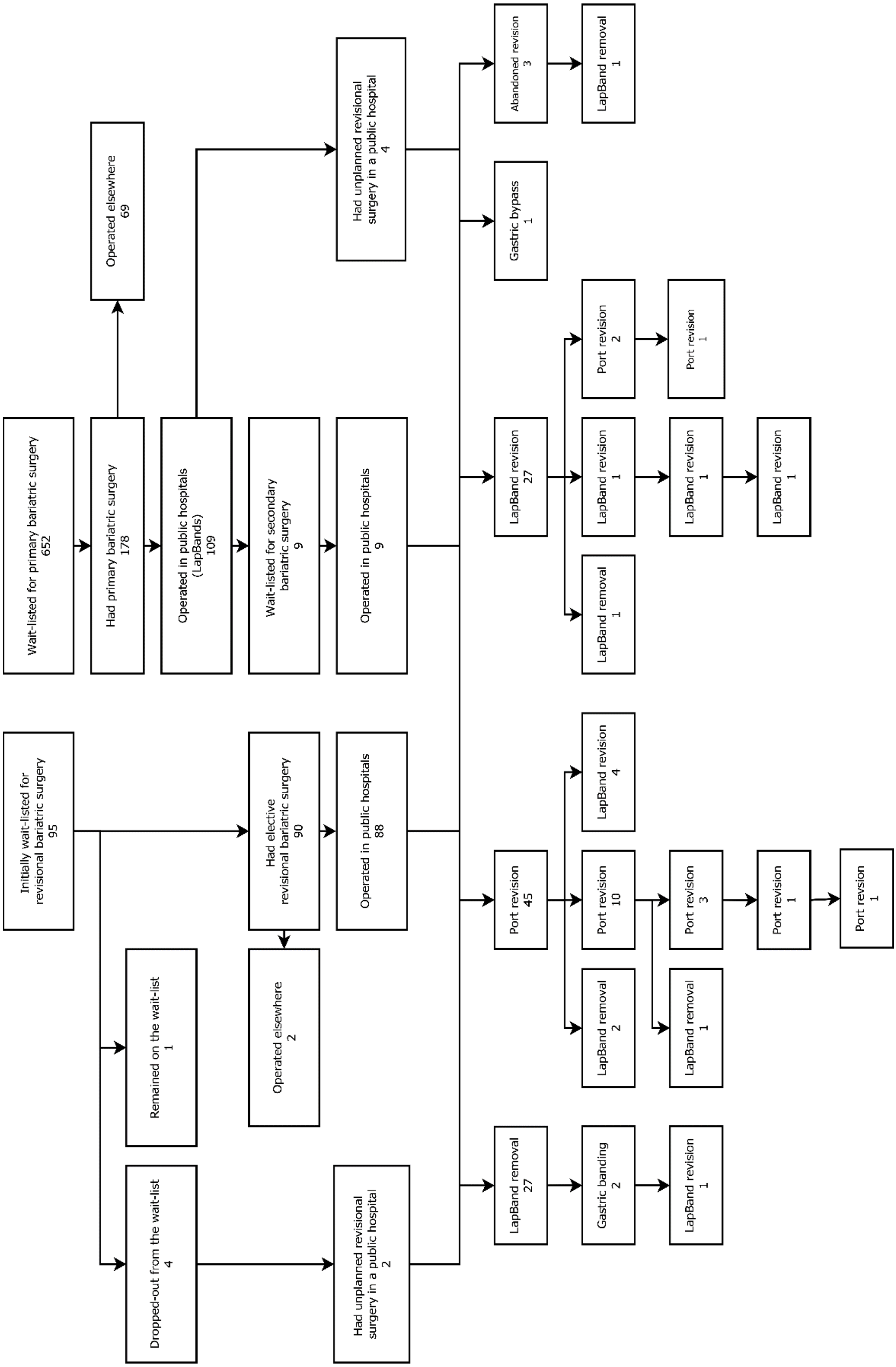

Figure 17. Detailed revisional procedures flowchart

Including 12 non-planned revisions (i.e., revisions that were performed without the patient first appearing on a wait-list), 142 (44.8%) revisional procedures were performed out of 320 procedures with public funding. When counting only the procedures performed in public hospitals, without the outsourced surgeries, 140 (56.2%) of 249 were performed for revisional surgery. When 62 minor revisions (LAGB-port revisions) were excluded, revisional surgery still constituted 78 (41.7%) of 187 bariatric procedures in Tasmanian public hospitals, or 80 of 258 (31.0%) publicly funded procedures.

5.3.2 Public hospital service use

We identified 1351 public hospital admissions and 2448 ED presentations for 165 patients who had only primary bariatric surgery (primary group), and 104 patients who had ever been wait-listed for revisional surgery (revisional group). Four patients who had a non-wait-listed (urgent) revisional surgery after a primary procedure were excluded from this analysis as they did not satisfy the definition of either group and did not have a revisional waiting period. The patients' characteristics are described in Table 20. There were no significant differences between the groups in age, sex or total observation time. The wait-list observation time was shorter for the secondary group due to shorter wait-list times.

Table 20. Patient characteristics*.

	Primary procedures only (Primary-only group) N=165	Ever wait-listed for revisional procedure (Revisional group) N=104
Age at time of first recorded wait-list placement, years (SD)	42.8 (11.3)	44.1 (10.2)
Males, % (n)	25.5 (42)	16.4 (17)
Aboriginal or Torres Strait Islander origin, % (n)	4.9 (8)	6.7 (7)
Observation time during wait-list period, years (SD)	**3.6 (2.1)**	**0.8 (1.1)**
Observation time after removal from wait-list, years (SD)	3.1 (1.6)	3.2 (1.7)

*Statistically significant differences are highlighted in bold.

The primary-only group had 40.3 admissions per 100 person-years while waiting for surgery, and 50.5 admissions per 100 person-years after the operation. The revisional group had a higher rate of hospital admissions both while waiting for revisional surgery (89.5 admissions per 100 person-years, IRR 2.60, 95% CI 1.63–4.13) and after the revisional surgery (97.4 admissions per 100 person-years, IRR 1.98, 95% CI 1.31–2.98). When comparing observation periods within groups, there was no significant change in admission rates after the surgery in either group (Table 21 and Table 22).

Table 21. Public hospital admission rates (unadjusted) per 100 person-years *

Revisional status	Number of admissions	Study period		
		On wait-list	Post wait-list	Total
Primary-only	497	40.3	50.5	44.9
Revisional	399	89.5	97.4	95.7
Total	896	46.9	68.8	58.8

Table 22. Adjusted* public hospital admission incidence rate ratios (IRR) with 95% confidence intervals

Revisional status	Period	
	On wait-list	Post wait-list
	IRR between groups	
Primary-only	1	1
Revisional	**2.60 (1.63–4.13)**	**1.98 (1.31–2.98)**
	IRR between periods	
Primary-only	1	0.98 (0.73–1.31)
Revisional	1	0.75 (0.51–1.09)

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold.

Similar trends were observed when analysing days of stay in hospital per year. Patients in the primary-only group had a rate of in-hospital stay of 1.0 day per person-year while waiting (0–68.8 days per year), and 2.5 days per person-year after the surgery (0–95.6 days per year). The revisional group had higher rates of in-hospital days per year both while on the wait-list for a revision (4.3 days per person-year, 0–62.8 days per year, 95% CI 1.44–4.99) and after the revisional surgery (3.7 days per person-year, IRR 2.10, 0–84.0 days per year, 95% CI 1.18–3.76). There were no significant changes between periods within groups (Table 23 and Table 24).

Table 23. Days in public hospital per person-year (unadjusted)

Revisional status	Days in hospital	Study period		
		On wait-list	Post wait-list	Total
Primary-only	1887	1.0	2.5	1.7
Revisional	1615	4.3	3.7	3.8
Total	3502	1.4	3.0	2.3

Table 24. Adjusted* days in public hospital per year incidence rate ratios (IRR) with 95% confidence intervals

Revisional status	Study period	
	On wait-list	Post wait-list
	IRR between groups	
Primary-only	1	1
Revisional	**2.68 (1.44–4.99)**	**2.10 (1.18–3.76)**
	IRR between periods	
Primary-only	1	1.21 (0.80–1.82)
Revisional	1	0.94 (0.57–1.55)

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold.

There was no difference in the ED presentation rates between primary-only and revisional patients while waiting for surgery (IRR 1.28, 95% CI 0.77–2.13). However, after the surgery, patients who did not require revisional operations (primary-only group) had lower presentation rates than those who underwent revision (IRR 1.76, 95% CI 1.15–2.70) (Table 25 and Table 26).

Table 25. Public hospital ED presentation rates per 100 person-years (unadjusted)

Revisional status	Number of ED presentations	Study period		
		On wait-list	Post wait-list	Total
Primary-only	750	66.2	64.6	65.5
Revisional	400	73.4	101.6	95.6
Total	1150	67.1	79.1	73.6

Table 26. Adjusted* ED presentation incidence rate ratios (IRR) with 95% confidence intervals

Revisional status	Period	
	On wait-list	Post wait-list
	IRR between groups	
Primary-only	1	1
Revisional	1.28 (0.77–2.13)	1.76 (1.15–2.70)
	IRR between periods	
Primary-only	1	0.97 (0.73–1.29)
Revisional	1	1.34 (0.88–2.02)

*Adjusted for age, sex and non-independent observation periods. Statistically significant differences are highlighted in bold.

5.3.3 Reasons for public hospital admissions and ED presentations

The most common reasons for hospital admissions and ED presentations were identified using major diagnostic categories (Table 27) and urgency related groups major diagnostic blocks (Table 28) respectively. The study did not have enough power to evaluate incidence rate ratios for specific reasons of public hospital admissions and ED presentations between groups and periods using the model adjusted for sex, age and non-independent periods, but the following trends were observed. In the revisional group after the surgery, there was an increase in admission rates for mental disorders (from 5.9 to 25.3 admissions per 100 person-years) and for digestive system disorders (from 6.9 to 12.7 admissions per 100 person-years). The revisional group had also disproportionally high admission rates in all periods compared with the primary surgery only recipients for mental disorders (20.8 vs 2.9 admissions per 100 person-years), diseases of the nervous system (16.1 vs 3.8 admissions per 100 person-years) and injuries and intoxications (15.9 vs 1.5 admissions per 100 person-years). We did not observe differences of similar magnitude in the ED presentations.

Table 27. Admission rates (unadjusted) per 100 person-years for the most common (≥50 admissions) major diagnostic categories (MDC).

MDC	Wait-list status	Absolute numbers for the total period		Admission rates per 100 py in periods		
		Admissions	Patients	Wait-list	Post wait-list	All periods
Mental D&D*	Primary-only	32	6	3.2	2.6	2.9
	Revisional	92	9	5.9	25.3	20.8
	Total	124	15	3.6	11.7	8.0
D&D of the nervous system	Primary-only	42	24	4.0	3.6	3.8
	Revisional	71	8	15.7	16.2	16.1
	Total	113	32	5.7	8.6	7.3
D&D of the digestive system	Primary-only	46	27	4.0	4.4	4.2
	Revisional	50	30	6.9	12.7	11.3
	Total	96	57	4.4	7.7	6.2
D&D of the circulatory system	Primary-only	76	30	6.5	7.3	6.9
	Revisional	16	10	3.9	3.5	3.6
	Total	92	40	6.1	5.8	5.9
Injuries, poisoning and toxic effects of drugs	Primary-only	17	16	0.7	2.6	1.5
	Revisional	70	41	21.6	14.1	15.9
	Total	87	57	3.7	7.2	5.6
D&D of the musculoskeletal system and connective tissue	Primary-only	50	31	3.7	5.5	4.5
	Revisional	27	13	13.8	3.8	6.1
	Total	77	44	5.1	4.9	5.0
D&D of the skin, subcutaneous tissue and breast	Primary-only	60	21	4.2	6.9	5.4
	Revisional	13	10	2.0	3.2	2.9
	Total	73	31	3.8	5.4	4.7
Factors influencing health status and other contacts with health services	Primary-only	20	19	0.5	3.4	1.8
	Revisional	38	14	5.9	9.4	8.6
	Total	58	33	1.3	5.8	3.7

* D&D - diseases and disorders

Table 28. Emergency department presentation rates (unadjusted) per 100 person-years for the most common (≥40 presentations) urgency related group major diagnostic blocks (URG MDB)

URG MDB	Wait-list status	Absolute numbers for the total period		ED presentation rates per 100 py in periods		
		Presentations	Patients	Wait-list	Post-wait-list	All periods
Other presentation	Primary-only	24	10	1.6	2.7	2.1
	Revisional	17	6	4.4	4.0	4.1
	Total	41	16	1.9	3.2	2.6
Injury (multiple sites, single site major and minor)	Primary-only	114	48	12.0	7.5	10.0
	Revisional	59	18	7.8	15.8	14.1
	Total	173	66	11.4	10.7	11.1
Circulatory system illness	Primary-only	116	40	9.4	11.0	10.1
	Revisional	46	24	7.8	11.9	11.0
	Total	162	64	9.2	11.3	10.4
Digestive system illness	Primary-only	95	45	6.8	10.2	8.3
	Revisional	52	30	13.3	12.2	12.4
	Total	147	75	7.6	11.0	9.4
Neurological system illness	Primary-only	79	35	9.6	3.5	6.9
	Revisional	29	16	7.8	6.7	6.9
	Total	108	51	9.4	4.8	6.9
System infection	Primary-only	58	18	4.4	5.9	5.1
	Revisional	16	9	2.2	4.3	3.8
	Total	74	27	4.1	5.3	4.7
Respiratory system illness	Primary-only	34	20	3.0	2.9	3.0
	Revisional	12	8	1.1	3.3	2.9
	Total	46	28	2.8	3.1	2.9
Psychiatric illness	Primary-only	24	10	1.6	2.7	2.1
	Revisional	17	6	4.4	4.0	4.1
	Total	41	16	1.9	3.2	2.6

5.4 Discussion

In this statewide population-based study, we were able to identify all patients wait-listed for public primary or revisional bariatric procedures during a 6-year period. For these patients, we identified all public hospital admissions and emergency department presentations along with non-planned revisional bariatric procedures with more than three years of postoperative follow-up, which represents significant increases in both time and follow-up proportions compared to most reported studies [13]. This study is also the first to focus specifically on public revisional bariatric surgery, which was previously mentioned only in registries and reports.

We demonstrated that revisional bariatric surgery constituted a large proportion of public bariatric surgery in Tasmania with the majority of revisional patients likely coming to the public sector after a primary procedure in private hospitals, and revisional bariatric surgery was associated with significantly shorter wait-list times compared with the wait-list times for patients waiting for a primary bariatric procedure. These findings are consistent with those from a recent study from South Australia, which also revealed that at least 51% of revisions in public hospitals followed previous bariatric surgery that occurred in the private sector, and with significant impact on the wait-list time for public surgery [18]. In our study, patients receiving revisional bariatric surgery also tended to come to the public sector from both public and privately funded primary bariatric surgery. This private-to-public patient transfer may occur due to the inability of patients to maintain private insurance for a prolonged time with some patients in our experience dropping their insurance shortly after obtaining their primary bariatric procedure. This can also occur when patients self-fund their primary procedure in a private hospital, and then cannot afford, or do not wish to have, revisional procedures in the private setting. With increasing numbers of patients having bariatric surgery, public resources may be tied up by revisional surgery, restricting access to primary surgery. Revisional surgery is an important part of managing these patients and must be reflected in policies and planning, especially when revisional surgery has higher priority rates as reflected by shorter average waiting times.

Our previous studies have shown that hospital service use does not decrease in the first years postoperatively after primary bariatric surgery (Chapter 2 and Chapter 3). In this study, we performed further sub-group analysis that showed that hospital service use did not change significantly for patients who have primary LAGB only. Adding revisional surgery patients to the analysis showed that patients requiring revisional surgery use more public hospital services than the recipients of primary surgery only, even when the hospital service use for the surgery itself is excluded from the analysis.

This study has some limitations. We were limited to public healthcare data and were not able to identify details of primary operations that occurred in the private system or primary surgery in the public system prior to 2006. We therefore had to assume that in some instances revisional surgery was for patients whose primary operation was in the private system, which was consistent with clinical experience.

The study focused on a cohort and time when laparoscopic adjustable gastric banding was the predominant procedure in Tasmania, but the findings, although not directly applicable to settings where other procedures are performed, still provide important information on the application of gastric bands in the public system.

The study results have implications for further planning of bariatric surgery in the public sector. Public health care should be ready to deal with an increasing burden of revisional surgery for patients coming from both the public and private sectors. Public health care should plan for not only the provision of surgery but also increased numbers of hospital admissions and ED presentations in the short- and medium-term, especially for patients requiring revisional surgery.

In addition to implications for decision-makers in the public system, our findings have implications for patients undergoing bariatric surgery in the private sector, who should be informed of the likelihood of further revisions, hospital admissions and emergency presentations and therefore advised to maintain their insurance if possible and ensure that their insurance policies cover the possible longer-term complications of bariatric surgery.

5.5 Conclusion

We conclude that (i) revisions constituted a substantial proportion of publicly funded bariatric surgery in Tasmania; (ii) patients requiring revisional surgery used more hospital services than primary surgery recipients before and after their respective surgery; (iii) bariatric surgery planning in the public sector should make adequate provision for revisional surgery patients to account for their more frequent and prolonged hospital in-patient stays and increased rates of ED presentations.

5.6 References

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Chapter 6: Discussion

6.1 General discussion

The conducted studies describe the influence of bariatric surgery on public hospital service use and, in particular, the impact of revisional bariatric surgery on public hospital admission rates and emergency department presentations in Tasmania. In addition to this analysis, different revisional surgery sequences were mapped, thus demonstrating the complexity of revisional bariatric surgery patient pathways. While providing some information, these studies also identified significant gaps in the current literature and policies that require further improvement and actions. While focusing on the laparoscopic adjustable gastric banding that was the predominant procedure in Tasmania during the study period, the results still have broader relevance, as we were also studying outcomes of those who were wait-listed and did not receive an operation. Moreover, the results of the study might guide policy makers in the choice of procedure to be performed in the public setting.

We did not find any decrease in public hospital service use rates for at least the first three years after bariatric surgery was conducted in Tasmania. This study did not explore the costs associated with public hospital service use. Moreover, costs are determined by not only the rates of service use but also the reasons for hospital admissions and emergency department presentations, which most likely changed after bariatric surgery. As discussed earlier, the possible changes in outpatient and primary care services use were not explored but can influence the total healthcare costs of bariatric patients.

Although the costs were not explored, with the current state of high demand for public hospital beds and the significant strain on the public system in Tasmania, costs are not the only major factor for policy makers to consider. A recent report released by the Australasian College of Emergency Medicine highlighted the increased risk to patients due to difficulties in accommodating hospital inpatients (access block) and breaching emergency department recommended assessment times. This problem is particularly evident in Tasmania, as well as in the Australian Capital Territory and South Australia [1].

At the current time, due to the low numbers of bariatric procedures in the public sector, bariatric patients are not making a substantial contribution to the access block problem. This, however, may change with any future expansion of bariatric surgery provision. As discussed in Chapter 3, the likelihood of being admitted to hospital from the emergency department increases after bariatric surgery and can possibly explain the findings of a significant increase in hospital admission rates without a significant increase in emergency department presentation rates after bariatric surgery.

One of the main conclusions of this study is that performing bariatric surgery in the public sector does not keep patients out of hospitals after primary surgery and does not decrease public health service use. Although bariatric surgery certainly provides many health benefits, it cannot be performed with the aim of reducing the demand for health services. In contrast, with the expanding provision of primary bariatric surgery, increasing demand is expected. As the recent Australian expert consensus on the treatment of obesity in the public sector stated, significant improvements are required in the provision of treatment for obesity, including establishing new services in areas of need and expanding the capacity of existing services [2], and we should expect increases in not only primary but also revisional bariatric surgery numbers. This outcome should be planned for pre-emptively, including by training surgeons to perform procedures complying with emerging policies and planning for increased admission and emergency department presentation rates in the short term and increased demand for revisional surgery in the medium and long terms.

Although the reasons for revisional surgery have been extensively investigated and include inadequate weight loss, weight recidivism (regain), or specific complications [3], the factors associated with inefficiency or even failure of secondary surgery requiring re-revision remain under-investigated. A longitudinal study from Portugal focusing on the psychological aspects associated with revisional surgery found that eating patterns after primary bariatric surgery may represent a factor compromising the success of revisional surgery and leading to further re-revisions [4].

Despite the absence of guidelines for revisional bariatric procedure choice, a recent survey of 460 bariatric surgeons from 62 countries revealed that there are certain trends in the revisional procedure sequence, with certain sequences favoured by the majority of the surgeons surveyed [5]. Roux-en-Y gastric bypass was the most favoured revisional option for all primary procedures. The majority of surgeons also incorporate allied health professional input in the management of revisional bariatric surgery patients. The survey also showed that 90% of bariatric surgeons consider demand in revisional surgery as mostly patient-driven despite funding by patient out-of-pocket expense in the practice of more than 50% of surgeons, with 46% public funding and 32% insurance funding in the surveyed practices. Due to the nature of the study, those figures may not accurately represent funding sources for revisional bariatric surgery, but they still demonstrate the importance of revisional surgery for the public sector and the lack of private insurance funding, which therefore limits patient access to revisional surgery and places pressure on public systems.

Although primary bariatric surgery lacks prioritisation guidelines, it has clear indications that allow the determination of the eligibility of a patient to receive a primary procedure in the public setting [6]. There are no clearly outlined indications for bariatric surgery, and moreover, there is no universally accepted grading of outcomes, with weight loss failure defined differently by different authors. A systematic review of definitions of failure in revisional surgery identified that the majority of studies do not define failure at all, and others use <50% or <25% of excess weight loss as cut-off points [7]. Weight regain also lacks a uniform definition [8], and applying different definitions for weight regain following sleeve gastrectomy to the same retrospective cohort resulted in regain rates ranging from 9 to 91 % [9]. Therefore, the introduction of a universally accepted definition of failure and weight recidivism in bariatric surgery should be one of the first steps in revisional guideline development. This step would allow the evaluation of the efficiency of publicly run bariatric programs, the identification of patients who might benefit from treatment escalation, and the selection of patients who can be offered treatment escalation in the public system if it is accessible. However, privately funded surgery may have different drivers for revisions, with providers or patients seeking earlier escalation of treatment, which would reduce the influence of any new guidelines.

This study identified the significant impact of revisional bariatric surgery on hospital service use in public healthcare, and further policy implications are required to regulate this largely overlooked area of bariatric surgery. There are possible options for policy applications depending on the outcome expected.

Given that revisional surgery in the public sector has shorter wait-list times and is associated with significantly lower drop-out rates compared with primary surgery, resulting in lower access to primary surgery for eligible patients, one of the simpler options is to separate the primary and revisional streams and create two independent wait-lists. Further development of this policy would consist of introducing prioritisation guidelines for both primary and revisional surgery.

Given the length of re-revisional pathways identified in our studies and the established demand for re-revisional bariatric surgery, one policy option to prevent tertiary and further procedures in the public sector could be a *One Revision Policy* of performing reversal procedures only. Removal of a gastric band is a technically safe procedure; however, patients are guaranteed to experience weight regain [10]. Reversals of Roux-en-Y gastric bypass are described in the literature as a feasible procedure; however, they are associated with significant morbidity [11, 12]. Another option would be to limit revisions only to patients with complications of bariatric surgery and not to perform revisions for insufficient weight loss or weight regain. The possible drawback of this policy is that it could result in placing a label of "treatment failure" on a significant number of patients without providing further effective treatment options in the public sector. There is also evidence that for certain categories of patients, such as those with refractory metabolic disease, revisions for inadequate weight loss or weight regain remain beneficial [13, 14]. The reasons for revisions in the public sector were not explored in this study and should be addressed in future research, as the impact of a policy limiting access to revisional surgery has not been explored. Such a policy will, however, contradict the currently accepted paradigm of treatment escalation and will differentiate bariatric patients from patients receiving other types of surgeries where revisions are common, such as coronary artery bypass grafting or total joint arthroplasty [15].

Another way to reduce the number of revisions in the public sector is to stop providing surgeries resulting in high numbers of revisions in the public sector. For example, in a recent study of more than 19,000 patients in the state of New York, the revisional rate for laparoscopic adjustable gastric banding (LAGB) resulted in revision rates of up to 34% during a 7-year period [16]. In a meta-analysis including 2,280 patients with sleeve gastrectomy with more than 7 years of follow-up, the overall revision rate was estimated to be up to 20%, with an estimated long-term weight recidivism rate of 28% [17]. It is not clear whether Roux-en-Y gastric bypass or single anastomosis gastric bypass is preferable in terms of revisional rates [18]. The United States national database study showed that insurance status influences the choice of primary bariatric surgery, with a larger proportion of LAGB recipients uninsured or having Medicare coverage compared with other types of bariatric surgery. Having a managed care insurance plan was a strong predictor of sleeve gastrectomy as a primary procedure [19]. Similarly, in Australian hospitals in 2014–2015, the proportion of LAGB performed in public hospitals was higher than in the private sector [20]. Therefore, the high revisional rates post-LAGB and high morbidity following its revisions, along with the high re-revisional rates identified in our systematic review, might discourage providers from offering LAGB as a primary or revisional bariatric procedure in a public system with the aim of reducing revisional burden.

Given the high numbers of patients who have already had LAGB and the continued use of this surgery in the private system, this measure will not have an immediate result. However, it is expected to contain the increase in revisional surgery numbers. The option of restricting access to LAGB in the private system can also be explored, such as by modifying guidelines, consensuses and bariatric society position statements to discourage LAGB as a primary procedure.

Surgeons should also be educated on policy implications as they may change their approach to patients with different insurance status and different insurance coverage. At the extreme, access for private patients self-funding their bariatric surgery could be limited if they are not able to afford further revisions.

Preoperative patient education can improve weight loss outcomes and reduce readmission rates [21, 22]. A qualitative study showed that patients can have unrealistic expectations about bariatric surgery, which lead to seeking revisions when these expectations were not met [23]. Therefore, patients should be educated on the expected outcomes and likelihood of revisional surgery, including the possibility of further re-revisions. This education also should include education on insurance implications, and self-funding or taking insurance only for a short time to be dropped after bariatric surgery should be discouraged.

This step might require additional actions from another player in the field – insurance companies – by providing extended coverage for bariatric procedures, such as covering all subsequent revisions required as part of treatment or reversals only, as discussed above. This extended coverage could take the form of an enforced policy or be used by insurers to create more attractive insurance plans. Moreover, this coverage could drive insurers to pay only for more effective surgeries with lower revisional rates and not fund revision-prone primary procedures or revisional surgeries with high re-revision rates, as well as limiting co-operation with bariatric centres with less-favourable outcomes. Some insurance companies in the United Stated have imposed conditions such as compliance with preoperative programs and mandatory preoperative weight loss [24, 25], and these mandatory requirements could be extended.

A key to the development of these policies and adjusting them for the greatest efficiency is long-term follow-up of all bariatric patients, private and public, and thorough capture of all outcomes. This follow-up is usually accomplished using bariatric registries, which are especially important for bariatric surgery for quality assurance and the development of strategies based on large-volume datasets applied to particular healthcare systems [26, 27].

The nationwide use of registries could also address the problem of not being able to follow-up due to interstate patient movements, as we were informed that some of the revisions for Tasmanian primary bariatric surgeries were performed interstate and therefore were not reflected in our studies. Without control of such outcomes, states might actually be interested in limiting interstate bariatric surgery transfer to optimise their policies in the setting of different policies applied at the state and national levels [28]. Moreover, if different access/outcome patterns emerge in long-term follow-up, this can justify differences in policy approaches, and *vice versa*, leading to standardisation if optimal pathways are found.

Future research should be prospective and capture a longer period of patient follow-up. It should focus on patient selection for primary bariatric surgery and wait-list prioritisation strategies and determine predictors of drop-out from wait-lists to optimise bariatric surgery delivery to patients who will benefit the most. Additionally, this will allow for better management of wait-lists and public healthcare service demands.

6.2 References

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